SECTION 300.00 - SIGNALS

SECTION 301.00 - INTRODUCTION

301.01 General. A traffic signal regulates and controls the movement of traffic and, accordingly, has a significant impact on traffic movement at an intersection. The MUTCD, as adopted by the state, outlines the minimum guidelines or warrants for when a traffic signal should be considered. However, the basis for a traffic signal installation is not the compliance with the warrant values but rather the traffic need. The warrant values are only guidelines indicating traffic volume ranges where the need for a traffic signal should be considered. As indicated in MUTCD Section 1A-09, the provisions of the MUTCD provide only standards for design and application of a traffic signal and are not a legal requirement for installation. Qualified personnel need to conduct an engineering study of a location, exercise engineering judgment in selecting the most appropriate traffic control, and if there is a need, install a traffic signal in accordance with the MUTCD and the following procedures.

301.02 Legal Authority. Traffic control signals shall be installed and operated in accordance with Department policy and specifications. Installation and/or operation of traffic control signals may fall under a cooperative agreement between the Department and ~~by~~ the public agency having jurisdiction of the roadway or roadways involved. Idaho Code provisions that are applicable to traffic signal installation are as follows:

49-121 DEFINITIONS

49-201 DUTIES OF BOARD

49-202 DUTIES OF DEPARTMENT

49-208 POWERS OF LOCAL AUTHORITIES

49-209 LOCAL TRAFFIC CONTROL DEVICES - Requires local traffic control device compliance with State adopted manual.

49-223 SALE OF NONCONFORMING TRAFFIC CONTROL DEVICES - Prohibits sale of devices that do not conform to the MUTCD.

49-640 VEHICLES APPROACHING OR ENTERING UNMARKED OR UNCONTROLLED INTERSECTION

49-701 PEDESTRIAN OBEDIENCE TO TRAFFIC CONTROL DEVICES AND TRAFFIC REGULATIONS

49-714 TRAFFIC LAWS APPLY TO PERSONS OR BICYCLES AND OTHER HUMAN-POWERED VEHICLES

49-720 STOPPING - TURN AND STOP SIGNALS (BICYCLES) - Permits bicyclists to slow to reasonable speed, yield right-of-way, and make right turn without stopping.

49-801 OBEDIENCE TO AND REQUIRED TRAFFIC CONTROL DEVICES

49-802 TRAFFIC CONTROL SIGNAL LEGEND

49-803 PEDESTRIAN CONTROL SIGNALS

49-804 FLASHING SIGNALS

49-805 DISPLAY OF UNAUTHORIZED SIGNS, SIGNALS, OR MARKINGS

49-806 LANE USE CONTROL SIGNALS

301.03 Department Policies And Directives. The following Administrative Policies and Highway Division Directives address traffic control signals on the state highway system: Administrative Policy A-12-16, "Traffic Control Devices and Highway Lighting," outlines the distribution of responsibilities and costs for traffic control devices including signals.

Administrative Rule 39.03.65, "Traffic Minute Entries," outlines responsibilities for traffic minute entries. A minute entry is not required for traffic signals or flashing beacons where they are covered by a cooperative project agreement. The policy provides that the district engineer may approve a minute entry for a flashing beacon warning sign installation.

Administrative Policy A-05-07, "Traffic Service Levels," requires that all traffic signals be maintained at service level "1" with replacement, repair, and maintenance in accordance with the Traffic Manual. See Section 300 of the Maintenance Manual for additional maintenance criteria.

301.04 Provisions For Future Installations. Traffic signal equipment should be designed and installed with future traffic needs considered, including contemplated highway improvements and flexibility in the operation of the signal control equipment. It is usually cost-effective and desirable to install underground conduit at an intersection even though a traffic signal may not be required until some indeterminate future date. Conduit for signal interconnection should be an integral part of any urban or suburban arterial improvement. Traffic signal pole installations should be offset to accommodate future intersection improvements. If right-of-way is being purchased, additional right-of-way for future traffic lanes should be considered.

301.05 Intersection Capacity Requirements. A traffic signal regulates the movement of traffic with one roadway stopped while other lanes or approaches are permitted to proceed through the intersection. As a result, any one approach to the intersection will be permitted to proceed through the intersection only 35 to 65 percent of the time. As a result, the existing traffic lanes will be used less than 50 percent of the time for vehicles to move along the street. Accordingly, a street will require additional lanes at a signalized intersection to carry the same volume of traffic as the street width between intersections. The planning and design of a traffic signal installation should include provisions for additional traffic lanes at the intersection so the signalized intersection provides the same roadway capacity as the adjacent uncontrolled roadway.

301.06 Signal Removal. Traffic signals are not always the best solution for a particular situation. Traffic flow patterns that at one time warranted signals may have sufficiently changed to render an operating signal no longer necessary. Responsible operating agencies should periodically evaluate the effectiveness and necessity for traffic signals against current signal warrants and remove those that are no longer warranted.

In 1980, the U.S. Department of Transportation, Federal Highway Administration, commissioned a study to establish criteria for the removal of signals that are no longer needed. The study recommended the use of a two-stage process for making the signal removal decisions including:

- Preliminary screening - a general process (shown in Figure 301.06-01) for application to a large group of signals that screens out those requiring further detailed analysis; and

- Detailed analysis - a process of detailed investigations (shown in Figure 301.06-02) of technical and social impacts of signal removal.

Use of such a documented engineering study approach is valuable in satisfying potential liability concerns. Further, it is useful in convincing the political decision makers and the general public that the signal removal decision was carefully assessed and expected to produce quantifiable, beneficial results.

Having made the removal decision, care should be taken in its implementation. The following procedure is recommended:

- Advise motorists of the impending change by placing the signal into flashing operation - main street yellow and cross street red. Supplemental information signs may be desirable

- Observe the operation at the intersection at the time the change to flashing operation is made to verify that it operates as planned. If it does, bag the heads and install stop signs on the cross streets.

- Observe the intersection again after about one week to verify that it is operating as planned. If it is, remove the traffic signal. It is recommended that this removal include all above-ground equipment such as signal heads, span wires, poles, controller cabinet, etc., leaving all foundations and anchor bolts in place, properly protected, for about six months. This permits cost effective reinstallation, if required due to operational experience.

- Monitor the intersection's accident experience and operation closely for at least six months.

It should be remembered that public reaction with regard to signals is typically to demand their installation in response to a perceived need. Rarely does the public demand the removal of a traffic signal. As a result, signal removal must be “sold” at both the citizen and the political levels to be successful.

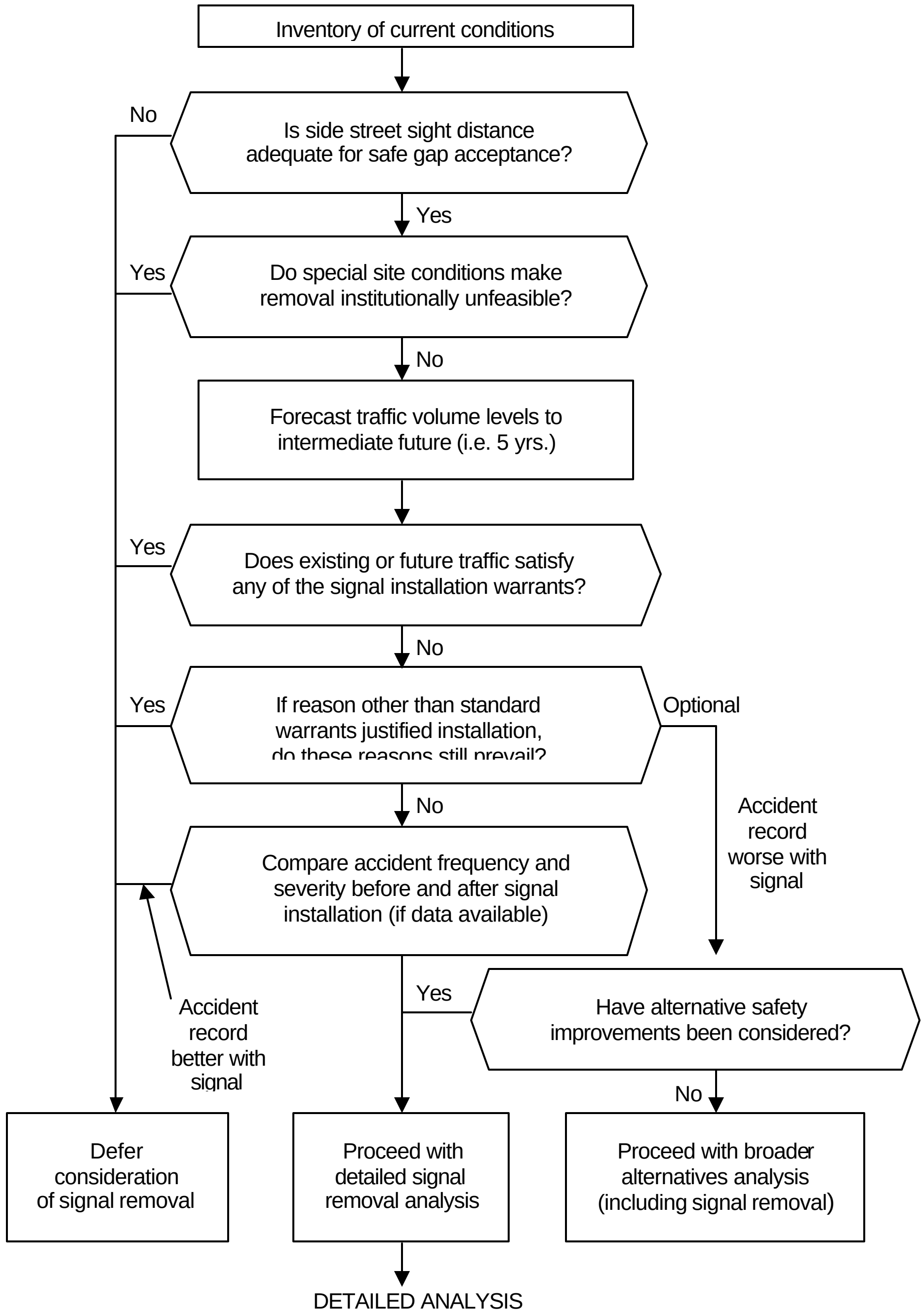


Figure 301.06-01 Signal Removal – Preliminary Screening

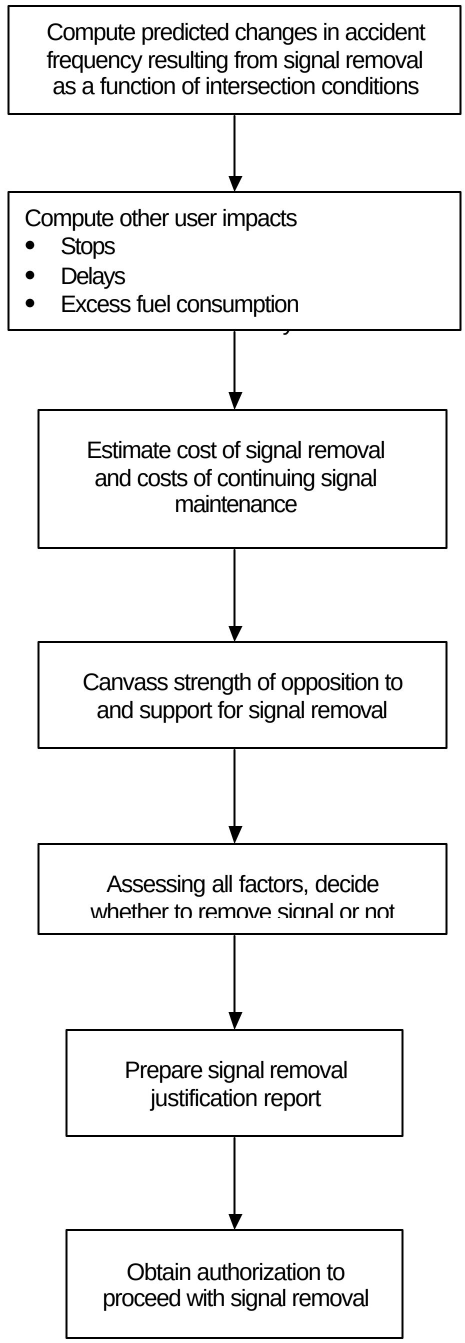


Figure 301.06-02 **Signal Removal – Detailed Analysis** (Source: FHWA-IP-80-12)

301.07 Purchase/Supply. The Headquarters Traffic Section purchases and maintains a supply of traffic poles, pole hardware, signal cabinets, controllers, and maintenance parts. This material is available through the normal Department supply channels. Additionally, ITD purchases signal poles, pole hardware, and controller equipment in large quantities and maintains annual contracts so this equipment is readily available for new installations or intersection upgrades. In the past, unnecessary contractor delays have occurred for several months until the contractor could obtain delivery of controller or poles. The Headquarters Traffic Section should request in writing from each district early in the project development stage, specific state-furnished materials needed for upcoming intersection projects so materials can be reserved and the budget process initiated.

The district should allow three weeks for Traffic Supply to assemble and ship traffic signal poles and hardware to the project site. Normally, pole anchor bolts are requested and provided prior to this pole shipment.

If the district or resident engineer contacts the Headquarters Traffic Section, the section will prepare a completed Supply Request Form, ITD-2379, transferring the material from Traffic Supply to the project. The form is forwarded to the district who can then arrange for the material shipment. This is desirable since the Headquarters Traffic Section will list all catalog numbers and ensure there are no oversights or a mismatch of components.

Traffic signal controllers should be requested at least ten weeks prior to the installation date. ITD "bench checks" all signal control equipment before it is installed at an intersection whether the controller equipment is state or contractor furnished. The Traffic Signal Shop personnel will deliver the approved controller to the project site. This ensures that the controller contains proper phasing and timing intervals, will not have major malfunctions, and meets the design specifications. This practice reduces the liability exposure of the state and permits any needed modifications in a controlled environment outside intersection traffic demands.

Several of the state purchase contracts and agreements permit Idaho city/county purchases at the same price by "piggybacking" the state order. Local officials desirous of obtaining signal equipment may want to check the state purchase contracts with the Headquarters Traffic Section to see if they can obtain the equipment they need.

301.08 Removal Of Confusing Advertising Lights. Advertising lights, Christmas decorations, or other devices located adjacent to the highway near an intersection that are similar in color and could be easily mistaken for a traffic signal sometimes interfere with the effectiveness of traffic signals and contribute to driver confusion and accidents. When this occurs, the property owner and local officials should be contacted and the problem explained to effect a change. For this reason, Christmas decorations or other lighting devices are not recommended for installation on traffic signal poles. In many communities, they are suspended at mid-block locations on their own supporting poles. Idaho Code 49-805 can be used as a supporting requirement to remove or relocate these conflicting lighting devices.

301.09 Closed Circuit Television Cameras. Operation of Closed Circuit Television (CCTV) cameras should be limited to viewing of the travel way(s) and adjacent right(s) of way. Care should be taken to protect the privacy of others outside the areas used by vehicular and pedestrian traffic.

SECTION 302.00 - SIGNAL APPROVALS

302.01 Traffic Signal Request. A request for a traffic signal can be initiated from the police, a public official, or within the Department either as a written or oral request. The request and contemplated intersection improvement shall be reviewed with the Headquarters Traffic Section prior to any commitment of ITD to a traffic signal installation. Receipt of the request should be acknowledged, with the requester advised of the need to collect data and make an engineering study of the location. It is also good public relations to advise the requester of the amount of time required before the engineering study can be completed. Once the study is complete, the requester should be advised of the study recommendations. These recommendations can take the following forms:

- A traffic signal is not needed for specific outlined reasons. If other traffic control is recommended instead of a traffic signal, this should be addressed.

- A traffic signal is not needed at this time but one may be required in a few years. This location will be maintained on our active list for additional field observation and study.

- A traffic signal is needed at this time, and a project request will be initiated for approval to obtain necessary engineering funds to develop the plans and specifications for the traffic signal installation. It should also be noted when they could expect the traffic signal to be in operation.

A traffic request could also initiate a need to approve or revise an existing traffic signal installation. This type of request should be treated in the same manner as a new signal request with acknowledgment, an engineering study, and recommendation. The only variation would be that the revision or signal improvement could be accomplished with state maintenance forces requiring less time and no approval of construction funds.

302.02 Engineering Study. The determination of need for a traffic signal requires the collection and analysis of field data to substantiate the necessity of the installation. Additionally, if a traffic signal is recommended, the data collected is also needed to design the traffic signal installation. It is inappropriate to determine need, then collect data to substantiate that need.

The MUTCD outlines the requirements for a comprehensive investigation of traffic conditions and physical characteristics of the signal location. The following variations from the MUTCD recommendations are permissible:

Traffic Counts - The traffic count shall include the peak eight hours of vehicular movement. This can usually be determined with a 12-hour turning movement count.

At a new location, not yet constructed, where it is possible to obtain only estimated traffic volumes, the projected traffic counts, turning movements, and basis for these estimates shall be provided in the study. The traffic signal need shall be based on current volumes, not forecasted volumes.

Vehicle Classifications - It is usually not necessary to include classification of vehicles where they are a normal percentage of the traffic volumes. Field observation of heavy commercial vehicle usage of the intersection should be noted, particularly if they impact turning maneuvers, increase approach delays because of property access or railroad crossings, or may add to the approach vehicle starting delays.

Pedestrian Volumes - If there are pedestrians using the intersection, they shall be counted during the same hours as the vehicle volume counts. Any special or erratic pedestrian maneuvers should be noted as well as classification of both school-age and elderly pedestrians. Field observations or the traffic turning movement count notations should verify the presence or absence of pedestrians.

Bicycle Volumes - The presence or absence of bicycles should be noted by field observation or notation in the turning movement count. Number, direction, and intersection usage will assist the designer in accommodating any bicycle traffic in the traffic signal design.

Collision Diagram - A collision diagram shall be prepared for the intersection, including at least the most recent three years of accident experience that is available. Warrants should not be considered for rear end or sideswipe collisions or for collisions as a result of driving under the influence.

Intersection Approach Speeds - The posted speed limits on each intersection approach shall be noted with 85th percentile vehicle speeds also provided, if they are available. Otherwise, a field sample of vehicle speeds determined through a limited field study shall be provided with special note of vehicles traveling generally higher or excessively lower than the posted speed limit. Recommendations relative to posted speed limit revisions should be addressed in the study.

Other Specialized Data - Special field data and traffic characteristics may be required for special traffic signal installations or traffic signal revisions. The data collection should be designed for the traffic characteristics to be determined, such as vehicle delay, pedestrian delay, vehicle gaps, gap acceptance, travel times, signal coordination, and intersection capacity.

The engineering study should include the data outlined in the MUTCD with noted variations, additional data as noted above, and comparison with MUTCD warranting guidelines. The traffic signal need is not justified by the fact that intersection volumes meet or exceed the minimum warranting conditions. The warrant values are only the lowest common denominator where most traffic engineers agree that a signal may be justified. If the location does not satisfy any of the warrant guidelines, then there is assurance that a traffic signal is probably the wrong solution to intersection operational problems. If the warranting guidelines are exceeded, then the advantages and disadvantages of a traffic signal, as shown below, shall be addressed in the engineering analysis to justify the signal installation.

Advantages	Disadvantages
Improve on daily movement of traffic	Increased delay to major traffic movements
Interrupt heavy traffic to allow side street traffic to cross or enter through street	Increased frequency of certain accidents
Increase traffic handling capability of the intersection	Reduced freedom of motorists to travel street network
Reduce frequency of accidents	Undesirable traffic diversion
Provide adequate gaps for safe pedestrian crossing	Motorist frustration and signal disobedience
Maintain traffic progression and vehicle platooning on an arterial street	Increased total intersection delay
	Need for additional traffic lanes to provide the same street capacity as the approaching roadway

It is usually necessary to supplement the data and data analysis with intersection observations during both the peak and off-peak periods. The following questions must still be answered to justify a traffic signal or address the reasons that a signal is not recommended:

- What are the intersection operational problems and how will a traffic signal alleviate those problems?
- Is the problem such that a traffic signal is the most economical solution?
- Would the delay to main street traffic be offset by the reduced delay to side street traffic?
- Would the delay to side street traffic be less with the traffic signal installation?
- Are there intersection traffic conflicts causing a significant accident problem that is only solvable with a traffic signal?
- Are there less restrictive measures that can be used to solve the operational problems, such as added turn lanes, rerouted pedestrian crossings, restricted turn maneuvers or private approach relocations?

If it is decided that a traffic signal is required, the traffic engineering study shall also address a preliminary recommendation of the following intersection and signal features:

- Intersection geometrics: Number of traffic lanes, turn bays, and special geometric features needed at each approach and considered in the traffic signal analysis.

- Traffic signal system: Recommended type of signal controller, signal system coordination, and preliminary phasing concept.

- Pedestrian requirements: Pedestrian crosswalk, signal indication, and walking prohibition requirements.

- Right-of-way requirements: Additional right-of-way required for existing and future intersection operations.

302.03 Traffic Signal Warrants. As noted in the MUTCD, a traffic signal should not be considered unless one or more of the warrant guidelines are satisfied. The engineering study outlined in the preceding section must analyze and justify the need for a traffic signal.

The warranting conditions outlined in Sections 4C.01 through 4C.09 of the MUTCD should be applied and are included as part of the engineering study.

The following requirements shall apply in tabulating the volumes for consideration of signal warrants:

- A separate right-turn movement that will operate without signal control shall not be included in the approach traffic volumes when considering warrant values.

- The number of lanes at an approach are reflected by the approach width available for traffic movement, not necessarily the absence of lane lines. Intersection operational improvement may be the restriction of parking or application of lane markings to provide additional approach lanes decreasing the signal requirement. Also, it may be appropriate and cost effective to increase the number of minor approach lanes rather than install a signal that increases delay for all vehicles.

302.04 Project Request. If a traffic signal is recommended under the Highway Development Program, the district shall initiate a Project Program Entry (ITD-1414). The engineering study and recommendations should be an attachment to the project request. If desired, the engineering study can be submitted for pre-approval to the Headquarters Traffic Section before the project request is initiated. The project request should outline all improvements such as intersection improvements, traffic signal work, and intersection illumination and should be coordinated with local jurisdictions.

If it is intended to upgrade an existing traffic signal installation by state maintenance forces, then the engineering study should outline the required equipment and material in a request to the Headquarters Traffic Section.

To avoid delay in development of signal projects, the following development schedule should be followed:

PRELIMINARY ACTIVITIES

Activity	Action By:
A. Determination of Need	District
1. Request Traffic Data	District
a. 12-hour turning counts	
b. Traffic forecasts	
2. Examine Accident Experience	District
3. Solicit City/County Desires	District
4. Prepare Traffic Engineering Study	District
B. Programming	
1. Submit Form ITD-1414	Submitted by District
a. Traffic engineering study	Approved by Traffic
b. Include intersection sketch	
c. Accident summary	
d. Traffic signal warrant sheet	
2. Request P.E. Authority	District
C. Preliminary Design	
1. Establish Design Control	Recommended by District
a. Intersection geometrics	Reviewed by Traffic
b. Type of controller (actuated, coordinated)	Approved by Design
c. Phasing	
d. Signal supports (mast arm, length, lighting, signs)	
e. Utility and other facility conflicts (include overhead and underground)	
f. Detection	
g. Interconnect	

h. Tentative division of work (city/state)

2. Discuss Proposal with City/County........District

3. Preliminary Design Review ....District, Design, Traffic, City/County

4. Approval Letter ....Design

INTERMEDIATE REVIEW

<u>Activity</u> <u>Action By:</u>

1. Rough Draft of Plans Prepared and Intermediate Review Requested ....District

2. Intermediate Review in District ....District, Traffic

3. Intermediate Review Letter ....District

FINAL DESIGN

<u>Activity</u> <u>Action By</u>:

A. Final Design of Signal Project ....District

1. Final Project Plans ....District

2. Final Design Review ....(FHWA), District, Design, Traffic, (City/County)

3. Final Design Review Report..................Design

4. Plans Sent to Boise ....District

B. Formal Agreement with City/County, Etc...........Local Roads

At least two months are required to prepare and obtain agreement approval.

C. Signal Material Ordered Traffic and/or City or Contractor

1. At least three months are required for delivery of signal controller and poles

2. State-furnished material is available in 30 days if needed material is in stock

3. At least 45 days are required to bench check and approve all controller equipment before installation

SIGNAL INSTALLATION

Request for construction authorities must be initiated by the district.

City, county, or state forces shall not charge materials or labor to a project until:

A. A formal agreement is signed.

B. The money required by the agreement is received from the city, county, or highway district.

C. The federal-aid programming is approved (if applicable).

D. The construction authority is issued.

E. A letter to proceed is issued by the Bureau of Operations.

Construction of the signal project may not proceed until the above-listed five steps, as appropriate, have been completed.

302.05 Traffic Signal Agreements. A traffic signal agreement is required for all traffic signal installations on the state highway system. The agreement defines installation, maintenance, replacement parts, electrical service responsibilities, and ownership between the state and the local jurisdiction(s), i.e., city or county. Even though the installation may be either totally the state's or LPA's responsibility, these current and future obligations shall be covered in an agreement between the public agencies. An agreement will be required for all traffic signal installations, including school-crossing and emergency-vehicle signals, school-crossing flashing beacons, and other-use traffic signal equipment that may be used to warn or regulate traffic. Since an agreement is required for all traffic signal installations, a traffic signal minute entry is no longer required. Section 307.00 provides additional details on agreements.

SECTION 303.00 - SIGNAL SELECTION PROCEDURES

303.01 General. Traffic signals are operated by an electronic controller that will recognize detection input, traffic volume changes, a time schedule, and many other factors to provide a wide variety of intersection timing patterns. The following definitions are provided to give a general understanding of traffic signal terminology:

Coordination - The establishment of a definite timing relationship between adjacent traffic signals. The coordination is maintained through interconnection of the signals by a communication or time-based system.

Controller - A device that controls the sequence and duration of indications displayed by traffic signals. It is normally an electronic unit and can be a computer that will require data input such as detectors or signals from other signal installations, pre-selected timing patterns, time-of-day schedules, and traffic presence in providing the best movement of traffic. A controller can be pre-timed or actuated, i.e., predetermined times that do not change or actuate where the traffic detected changes the timing pattern.

Detector - A device to detect the presence or passage of a vehicle in the roadway such as a loop detector.

Signal cycle - The time required for one complete sequence of all traffic signal indications or the timing for all signal phases provided by the controller.

Signal phasing - Any part of the traffic signal cycle allocated to any movement or combination of traffic movements receiving right-of-way in the intersection, i.e., main street left turn.

Timing - The individual time intervals for various controller functions that make up the phase time and cycle length. These can be green time, clearance interval, vehicle interval, etc.

Traffic signal installation - All the components of a signalized intersection including poles, signal heads, controller, detection system, and interconnection with other signals or data sources.

303.02 Controller Selection. There are two basic control strategies for traffic signal operations: pre-timed and actuated.

The pre-timed operation provides a fixed sequence of timing intervals and phases on a predetermined pattern. Most pre-timed equipment is capable of changing the pre-timed cycles by command such as time-of-day or other information from an external source such as a master controller or computer system. Pre-timed controllers are normally used in a signal network system where the traffic volumes are predictable, coordination of the system is highly desirable, and timing requirements do not vary significantly.

The actuated operation has the ability to adjust its timing within specified limits to respond to traffic conditions of that moment as registered by detector actuations. This allows the actuated controller to skip phases where there is no traffic and provides more “green” time on those signal phases with the most traffic at that time.

The type of controller selected is also influenced by the type used at adjacent intersections, signal network considerations, and the maintenance capabilities of the local community. The controller selection shall be reviewed with the Traffic Section and local officials.

303.03 Pedestrian Control Applications. Pedestrian control at intersections can be affected using any of the types of operation described above for vehicle control. The most important thing to remember with regard to pedestrian treatment at signalized intersections is that every pedestrian is entitled to a signal display that will allow him/her to legally cross the street. He/she is further entitled to receive that display with enough time to make the crossing safely under normal circumstances. This is generally not a problem at intersections where pedestrian signals are used, but the pedestrian is often forgotten at other intersections, especially where the pedestrian traffic volume is very light and at complicated intersections such as diamond interchanges. There are very few intersections, however, at that the likelihood of pedestrian traffic is so remote that pedestrian considerations are not necessary.

There are three modes of pedestrian control at an intersection: control by pedestrian signals in both concurrent and exclusive modes and control by vehicle signals.

- **Control by pedestrian signals - movement concurrent with vehicles.** This type of pedestrian operation is normally used in Idaho and involves the use of pedestrian signals, with the pedestrians moving concurrently with and parallel to the vehicle traffic. This type of operation is especially useful at intersections with phasings that may be difficult for the pedestrian to easily comprehend: at intersections where there is a need to exercise more positive control over the pedestrian (such as stopping him early or starting him later than the vehicles in order to aid turning traffic) and at intersections where one or more of the crosswalks is a designated school crossing.

- **Control by pedestrian signals – exclusive pedestrian phase.** Pedestrians at some locations are granted a totally separate (exclusive) phase for their movement. While this type of operation may be justified at a few special locations, its implementation where not clearly justified should be vigorously opposed, because it unnecessarily delays both vehicles and pedestrians and, if the location is within a coordinated system, it can render coordination ineffective. Exclusive pedestrian phases have been used where pedestrian volumes are high (hundreds of pedestrians an hour) and the conflict between these pedestrians and turning vehicles is either unnecessarily hazardous or results in unacceptable intersection capacity. When used, exclusive pedestrian phases allow pedestrians crossing all approaches to move simultaneously and also may allow diagonal crossing of the intersection. Pedestrian signals shall always be used to control pedestrians when exclusive pedestrian phases are used. The adverse effect of exclusive pedestrian phases can often be minimized by designing the control equipment to provide the exclusive phase only during the periods when it is really needed, using concurrent pedestrian operation at other times.

- **Control by vehicle signals.** Another mode of pedestrian control is where the pedestrian is controlled only by the vehicle signals and moves concurrently with and parallel to the vehicle traffic. This is the traditional mode of pedestrian control but is not recommended for traffic signal installations on the state highway system in Idaho for the following reasons:

  - It is difficult for the pedestrian to recognize the various signal indications so they do not understand when they can cross the street.

  - It is not possible to provide vehicle timing so an adequate pedestrian crossing time is guaranteed.

  - It is ITD's philosophy that pedestrians deserve and should have positive traffic signal indications to safely accommodate their use of the intersection.

In general, all crosswalks (whether marked or not) at an intersection should be provided with adequate pedestrian control so that the freedom of movement of the pedestrian is not unnecessarily abridged, because pedestrians will often attempt to cross even where prohibited if they deem it convenient. This is especially true at T-intersections, where there is a temptation to install pedestrian control for only one crosswalk parallel to the stem of the T. There may be cases where one of the movements from the stem of the T is so heavy that pedestrians should not be allowed in conflict with it. This, however, should be the exception rather than the rule. Intersections that have unusual geometry or phasing may require that certain pedestrian crossings be disallowed for safety reasons. In all cases where adequate pedestrian control is not provided for a crosswalk, crossings using that crosswalk should be prohibited through the use of appropriate signs strategically placed for pedestrian observance. In some locations, physical barriers to the crossing may have to be erected if crossing prohibition is necessary.

At pre-timed intersections, care must be taken to ensure adequate pedestrian crossing times on each applicable phase. Care should also be taken to maximize the amount of WALK time, so that pedestrians are not unnecessarily inconvenienced, without unduly extending the cycle length. For instance, assume that the green plus yellow time for a phase is 30 seconds and that the required pedestrian clearance is 12 seconds. Maximizing the WALK time would result in a WALK time of 18 seconds, instead of the considerably shorter minimum permissible WALK time.

At actuated signal installations, the pedestrian must gain access to the signal sequence in the controller. The pedestrian will require a means of calling for the right-of-way through the use of a pedestrian push button. A pedestrian push button is located on each corner with a push button for each pedestrian crossing phase. This push button is connected to the pedestrian detector input of the associated phase of the controller. When actuated, this input will cause the controller to serve the associated pedestrian movement at the proper point in the signal sequence.

Intersections that must accommodate pedestrians must be equipped to provide the pedestrian enough time to safely cross the street. This is true whether or not the intersection is equipped with pedestrian signals. A pedestrian is permitted to cross at an intersection by watching the vehicle signal in an implied crosswalk if one is not marked. Therefore, the signal timing should always provide minimum pedestrian crossing time even though there are only random pedestrians occurring at the intersection with no pedestrian signals or marked crosswalks provided. The minimum phase times necessary for vehicle traffic are generally shorter than required to ensure safe pedestrian crossing times. To enable pedestrians to obtain sufficient crossing time, without increasing the minimum cycle length on a full-time basis, actuation of the pedestrian push button for a phase will cause the phase time to be extended appropriately during the next signal cycle. In the absence of other pedestrian actuations, the signal will return to and operate on the shorter vehicle cycles.

At pre-timed coordinated intersections, the background cycle, with regard to the major street through-traffic phases should be timed to accommodate pedestrians every cycle. Furthermore, such phases should normally be operated so that the WALK signal is displayed every cycle. For the side street phases, the background cycle should be similarly timed. At actuated coordinated intersections, the WALK signal would only be displayed upon pedestrian actuation. The background cycle need not be set up to accommodate pedestrians every cycle, but the controller's pedestrian timing must still be adequate to serve the pedestrians upon actuation of the push buttons. In this case, actuation of the pedestrian timing will cause the controller to be out of step with the coordinated system for a cycle, but this is better than inconveniencing all of the vehicle traffic all of the time when pedestrian traffic is sporadic. When set up in this manner, actuation of the push button will cause the signal to be considered off-line by the system until the pedestrian timing is completed. In order for the signal to be brought back under system control after the pedestrian activity, the pick-up parameter in the intersection's system database must be set for short way re-synchronization rather than for smoothed or dwell-type re-synchronization. However, this type of re-synchronization may actually skip phases to get back in step. If smoothed re-synchronization is used, the signal will remain out of step with the progressed timing for several cycles.

303.04 Other Information. Other information on signal controllers, detection, timing, determination and coordination are contained in manufacturer's information or the following publications:

Manual on Traffic Signal Design, Institute of Transportation Engineers, James H. Kell and Iris J. Fullerton, 1998.

Traffic Engineering Handbook, Institute of Transportation Engineers, James L. Pline, 1999.

Traffic Detector Handbook, 2nd Edition, FHWA-IP-90-002, July 1990.

Traffic Control System Operations: Installation, Management and Maintenance, Institute of Transportation Engineers, James M. Giblin, Walter H. Kraft, James Rudden and Robert Sands, 2000.

SECTION 304.00 - COORDINATION AND SIGNAL SYSTEM PHILOSOPHY

304.01 General. The greatest benefits to the public for each dollar spent on traffic operations improvements come from the coordination of adjacent traffic signals to provide smooth movement of the traffic through groups of signals. Coordination is generally accomplished through the use of traffic signal systems. This section of the manual discusses the philosophy of coordination and the means to achieve and effectively use it to facilitate the movement of the public.

304.02 Need For Coordination. The coordination of traffic signals to facilitate smooth traffic flow (progressed movement) along a street or streets is a proven technique. The quality of such smooth flow along a street is basically a function of the spacing of the signals along the street, the prevailing speed of traffic on the street, and the traffic signal cycle length. The amount of traffic on the street and at the signalized intersections and the proportion of the green time given to the progressed movements are also important.

Many people have attempted to identify an upper limit on the distance between signals above which coordination should not be attempted. There is no fixed limit. The goal of coordination is to get the greatest number of vehicles through the system with the fewest stops in a comfortable manner. It would be ideal if every vehicle entering the system could proceed through the system without stopping. This is not achievable, even in well-spaced, well-designed systems. However, coordination should not be sold short. In systems where the signal spacing is less than ideal, significant benefits can accrue from coordinating the signals. Even if 25 percent of the traffic is stopped by the system, that is still much better than stopping 50 percent or more of it, as would happen on average under uncoordinated operation. Therefore, if you think coordination might work, try it. Where inter-signal distances are long, you may have some platoon dispersion, but if most of the platoon is served as you planned, the coordination is worthwhile.

In addition to the question of when signals should be coordinated, there is a companion question of where a group of signalized intersections should be subdivided when such subdivision is needed to provide better service.

The coupling analysis is a useful, easy-to-use tool for determining whether or not to try coordination and where control area boundaries should be placed when subdividing a group of coordinated signals. This analysis uses a coupling index, which is nothing more than the ratio of the two-way traffic volume on a link between signalized intersections to the length of the link. The index equation is:

$$I = V/L$$

Where: I = coupling index

V = 2-way hourly volume on the link in vehicles per hour

L = length of the link in meters (feet)

Note that for analysis purposes, the units of the coupling index are meaningless.

For planning purposes, a coupling index of 0.3 or more during any hour would indicate the desirability of including the signals on the link in the coordinated system. For operational purposes, a coupling index of 0.5 or more would indicate that the signals should be coordinated during the period under consideration if they can be operated on a compatible cycle length. The 0.5 level also is useful in identifying probable control area boundaries.

It is suggested that the coupling indices be plotted on a map by time period. This will help the engineer gain a “feel” for the make up of the traffic signal network as a whole. Such a map will also be very useful for guiding decisions about priorities of progression when several links at an intersection require progressed movement.

It should be noted that the intended purpose in using the coupling analysis is to have a logical but simple method of aiding the signal engineer in determining the need for coordination. When used, it provides the data for a simple “first cut” at the need for coordination in the “gray” areas. In most cases, the judgment of the engineer for 95 percent of the links will be all that is needed. The value of the coupling analysis is in evaluating the small number of links where the need for coordination is not apparent to the engineer. In all cases, the judgment of the engineer should prevail and should consider the relative character of the intersections and the compatibility of the cycle lengths. It should be understood that the coupling index values stated above were arrived at empirically and have no significance beyond their apparent usefulness. The engineer may find it useful to evaluate networks at several different coupling index thresholds.

304.03 Factors Affecting Progressed Movement. There are a number of factors that can limit the ability of a signal system to provide high quality progressed movement along a street. These factors include irregular inter-signal travel time, incompatible signal cycle requirements, the proportion of the cycle time available to the progressed movements at the various intersections, and traffic congestion.

It should be kept in mind that the discussion that follows is intended to be understood on a time-period or timing plan basis.

304.03.01 Irregular Inter-signal Travel Time. The best progressed movement can be provided when the travel times between the signals at the ends of each link are about equal. This is because there is an interrelationship between the speed of travel, the link length, and the optimum signal cycle length. In fact, however, there are very few signal systems that enjoy regular travel times. This does not mean that coordination is not beneficial, but it will not generally be possible to obtain all of the benefits that would have been possible if the travel times were about equal.

304.03.02 Incompatible Signal Cycle Requirements. In order to provide progressed movement through a group of signalized intersections, it is necessary to operate all of the intersections on the same cycle length. Usually, however, the cycle requirements differ from intersection to intersection. To achieve coordination of the signals, they will normally be operated on the minimum cycle length that will satisfy all of the intersections. This is not a problem as long as the cycle length required is within an acceptable range for all of the intersections. If it is not, some compromise must be made to achieve the benefits of coordination in an acceptable manner. This may involve one or more of the following actions:

- Operating one or more intersections in the isolated mode while coordinating the rest.
- Dividing the group into two or more control areas, each coordinated on an appropriate cycle length.
- Operating the critical intersection(s) on a slightly shorter cycle length than required, tolerating the resulting congestion on minor phases.
- Operating some of the intersections at twice (or even three times) the basic cycle length.

Systems operated under such compromises will not provide all of the benefits of coordinated operation that would have been available if all of the signals could have been operated on a common cycle length, but they will generally provide significant benefits.

304.03.03 Proportion of Cycle Time Available to Progressed Movements. It is basic that the quality of progressed movement will improve with the amount of green time that is available to the progressed movements at the various intersections. This is especially true in systems where the travel times are not reasonably equal. It is important that care be taken to maximize the coordinated phase green times when progressed movement must be provided. The number of signal phases should be minimized so as not to unnecessarily restrict the coordinated phase green time. Physical improvements to the intersection should also be considered as a means of increasing the amount of green time made available to the progressed movements. In this regard, it is important to provide as much capacity as possible on the side street and minor phases so that their time requirements are held to a minimum, providing more green time to the major street for progressive movement. Without such actions, physical capacity improvements for the progressed movements may actually be counterproductive for progression, since they will enable the intersection to serve the coordinated phase traffic in less time on an isolated basis.

304.03.04 Traffic Congestion. Traffic congestion on the coordinated phases at many intersections is an unavoidable fact of life. The degree to which such congestion affects progressed movement depends upon the amount of congestion.
At many locations, the coordinated phase is congested because of the amount of traffic entering the link from sources other than the upstream signal’s coordinated phase. In such cases, it is often possible to reduce the signal’s offset and even increase the coordinated phase’s green time to allow the stopped traffic to move out ahead of the approaching platoon.

At other locations, there simply may be more traffic than the intersection can process. In such cases, progressed movement through the intersection may be impossible to achieve; however, it is quite possible to achieve progressed movement away from the intersection.

There will, of course, be some intersections at which the congestion is so severe and the required cycle length so high with respect to the cycle lengths at the other intersections that it is best to operate the signal in the isolated mode. This may be true even if the signals on each side of it are operated in the coordinated mode.

304.04 Operations Philosophy. There are three areas of signal system operation where it is appropriate to consider the philosophy of operation. These three areas are:

- What mode to operate in
- How often to change timing plans
- Whether to implement traffic-responsive operation

These considerations need to be considered on a control area basis and on a time-period basis.

In considering each of these areas, the ultimate goal is to provide an operation where the benefits outweigh the disadvantages.

304.04.01 Mode of System Operation. In designing system operation, the engineer must decide when to operate each intersection in the coordinated mode, when to leave it isolated, and if and when to flash it. Further, at actuated intersections where cross-street progression or minor phase progression is required during certain time periods, the engineer must decide when to recall such minor phases and whether they should be forced to extend to their maximum limits or not.

Because the traffic on collector roads and higher type roads is usually constant and of significant magnitude, a good rule of thumb is to operate intersections on such roads in the coordinated mode except when they can be flashed. The rationale for this is that, in general, if there is sufficient coordinated phase traffic to require operation of the signal, there will be a positive benefit from the coordinated operation that will outweigh the minor phase delay.

There are obviously conditions that would exist that would require the choice of isolated operation; however, in general it is better to opt for coordinated operation when such a signal must be in operation. Cases that might require isolated operation are:

- The predominant traffic occurs on an uncoordinated phase.

- The cycle length required by the intersection is higher than the cycle lengths required by most of the other intersections in the control area <u>and</u> the progressed movement that would be provided on that cycle length is considerably inferior to that which could be provided through the other intersections on a lower cycle length.

- The cycle length required by the intersection is lower than the cycle lengths required by most of the other intersections in the control area, there is considerable delay to the minor phase traffic, <u>and</u> there are significant gaps in the coordinated phase traffic. In such cases, it may be appropriate to operate the intersection at one-half the cycle length of the other intersections. The decision to operate the signal in the isolated mode in this case may be affected by whether or not the system is designed to provide a “permissive yield” period.

Where the need for coordination is marginal, it is best to err in favor of coordinated operation until observation reveals that isolated operation would be better.

If system signals composed of pre-timed and semi-actuated controllers are to be flashed under light traffic conditions, it is best to place all signals that are to be flashed in a given control area into flashing operation at the same time.

304.04.02 Frequency of Timing Plan Changes. In general, it is a good idea to match timing plans to traffic conditions in order to provide the best service. Many systems provide automatic traffic-responsive capabilities with the goal of maximizing this match. The appropriateness of traffic-responsive strategies is discussed below. Here we will consider the selection of timing plans on a time-of-day basis.

The question of how often to change timing plans to match traffic conditions involves several factors. These are:

- The degree to which traffic characteristics change in either amount or directional distribution throughout the day.
- The quality of progressed movement that can be provided by the various timing plans.
- The size of the control area.
- The timing plan transition method used and the cycle lengths involved.

If traffic characteristics remain relatively constant for long periods, the need for timing plan changes is obviously small. Furthermore, there are many control areas where a specific timing plan is so good that it will serve a range of different traffic conditions and thus reduce the need for timing plan changes.

Because of the time required to change timing plans and the associated disruption in progressed movement, it is generally accepted practice to limit the frequency with which timing plans can be changed. In many systems, timing plans cannot be changed sooner than 15 minutes after the last plan change. Some systems lock out changes for a fixed number of cycles following a change, while other systems allow the lock-out period to be selected as a fixed number of seconds or cycles.

Most engineers agree that it is counterproductive for a timing plan to be in effect less than 15 minutes. A useful rule of thumb is that timing plans should be in effect for at least the greater of 15 minutes or ten times the travel time of a progressed platoon following the longest planned route through the associated control area.

304.04.03 Appropriateness of Traffic-Responsive Operation. In concept, the idea of automatically matching timing plans to traffic conditions seems desirable. Many systems have been designed to automatically select or construct timing plans in response to the activity of traffic registered by detectors in the street. However, most such systems have been operated primarily in the time-of-day mode in actual practice. The reason is that there are a number of problems with traffic-responsive operation.

The first problem is with the concept itself. The system cannot implement a timing plan change until it detects a significant change in traffic. This “response” generally takes from 10 to 15 minutes. This is because the system requires some minimum amount of time (typically five minutes to ten cycles) to recognize that a change has taken place and then it requires time to actually affect the timing change as discussed above. The problem is that in many areas, the traffic peaks only last 10 to 15 minutes. By the time the system has responded, the peak is over, or nearly so. Some jurisdictions have tried to overcome this problem by using time-of-day control to prepare the system for the peaks and allow the traffic-responsive operation to control the system at other times. Under such scenarios, it is questionable how much actual efficiency the traffic-responsive feature adds to the traffic flow. A problem related to this is that it is often not possible to identify detector locations that will give a clear indication of certain traffic conditions, most notably the occurrence of the afternoon or outbound peak. This problem is most pronounced in smaller control areas (those with fewer than 10 signalized intersections between the location of outbound traffic origin and the control area boundary) when the outbound traffic originates within the control area.

The engineering effort necessary to implement traffic-responsive operation is considerable. Engineering effort must be expended to identify appropriate detector locations and to establish all of the traffic-responsive parameters for these detectors. This is a large task, even if the number of detectors is kept small. Many systems also require that reasonableness parameters for the activity at each detector be specified. It is not uncommon for the engineering associated with the implementation and fine-tuning of traffic-responsive operation to take as long as, or longer than, the development of the timing plans. Considering that most systems serve traffic that is sufficiently predictable that time-of-day control is quite adequate, that the added efficiency that can be derived from traffic-responsive operation is only a few percent at best, and that the likelihood of actually realizing that added efficiency is slim, it does not appear wise to expend this level of effort to implement such operation. The available resources could better be utilized updating the timing plans.

There are two instances when traffic-responsive operation can prove useful. One is very specialized and the other could be considered a form of system preemption.

In instances when traffic changes are truly unpredictable <u>and</u> where it is possible to detect them in time to respond adequately, traffic-responsive operation can be beneficial. An example of such a case exists in Clearwater, Florida. Clearwater's traffic is normally fairly predictable - until it rains. When it rains, all of the people on Clearwater Beach leave the beach via State Road 60 through the center of the city. Obviously, it is not possible to schedule timing plans to accommodate the rain! Before the traffic enters the signal system, it must traverse a long causeway, providing an opportunity for it to be adequately detected so that special timing plans designed to flush the beach traffic can be implemented.

A second beneficial use of traffic-responsive operation is on roadways that are subject to long delays due to railroad or drawbridge activity. In such cases, the system can be designed to detect the railroad or drawbridge activity and to monitor the lengths of the traffic queues that form as a result. When the activity ceases, special traffic-responsive algorithms can implement special timing plans to flush the backed up traffic. These plans will be chosen based on the lengths of the queues in each direction.

304.05 Safeguarding Progressed Movement. It is often difficult to develop timing plans that will be effective in facilitating the progressed movement of traffic. Timing plans are quite sensitive to the speed/signal spacing relationship that exists on a street. For this reason, the installation of traffic control signals should be scrutinized very closely, not only to be sure the signal is really needed, but also to be sure that its installation will not unnecessarily disrupt the progressed movement of traffic.

In this regard, a traffic progression plan should be developed to safeguard the ability to provide progressive movement along various corridors. Such a plan would give cognizance to those existing signals that must remain and would identify probable future signals that cannot be avoided. A target timing plan would then be developed for these. This target timing plan can then be used to identify locations where new signals can be tolerated without causing a deterioration in the progressed movement. This plan, when adopted, can be used in the development review process to guide development in such a way that new signals will not be needed or where they cannot be tolerated.

304.06 Timing Plan Development And Maintenance. A few words are in order about the process of timing plan development and maintenance. A signal system is only as good as its timing plans. In general, the timing of each control area should be reviewed and updated as needed at least once a year. When a control area is subject to seasonal variation of traffics the plans for each season should be reviewed and updated at least annually.

This is a time-consuming task that will require a commitment of at least 10 engineering man hours and 20 technician man hours per signal per year. It should be noted that this commitment is required just for timing and fine-tuning the signals. It includes the needed data collection but does not include other tasks such as signal warrant studies or signal design.

The engineer should spend a significant portion (one-eighth to one-fourth) of his time driving and observing the coordinated streets to identify locations that can be improved. The effectiveness of this time can be maximized by having a technician do some of this driving and recording the results on an automated travel time/delay system.

There are a number of computer programs for timing plan generation available to aid the engineer in the timing task. ITD uses Synchro Ver. 5 for arterial timing and interchanges, and TRANSYT-7F for grid networks that are described below. The Headquarters Traffic Section will assist the districts in running these timing models and explain implementation.

304.07 Time-Space Diagram. In order to obtain the most efficient utilization of progressive signals on a given through street, they must be carefully fitted to the traffic conditions. Field counts at appropriate times, for both the street in question and for important cross streets, determination of cycle length, cycle divisions, and appropriate offsets are required in order to determine the proper timing for coordinated progressive movement along a signalized street.

The "cycle length," the time required for a complete sequence of indications, ordinarily falls between 50 and 140 seconds. Short cycle lengths are to be preferred, as the delay to standing vehicles is reduced. However, the timing requirements for pedestrian phases may control minimum cycle length. With high volumes of traffic it may be necessary to increase the cycle length to gain added intersection capacity.

By using the street length for the entire system, and cycle divisions for each intersection, the offsets in timing between the signal indications of the different streets can then be worked out by graphical or analytical methods.

The graphical solution is based on a time space diagram that has distance along the street as its ordinate and time in seconds as the abscissa (Figure 304.07-01). On this graph, the slope of any straight line represents velocity, since the units are distance and time. By trial and error an offset time can determined for each street that will provide a through band width to best utilize the signals under the existing conditions.

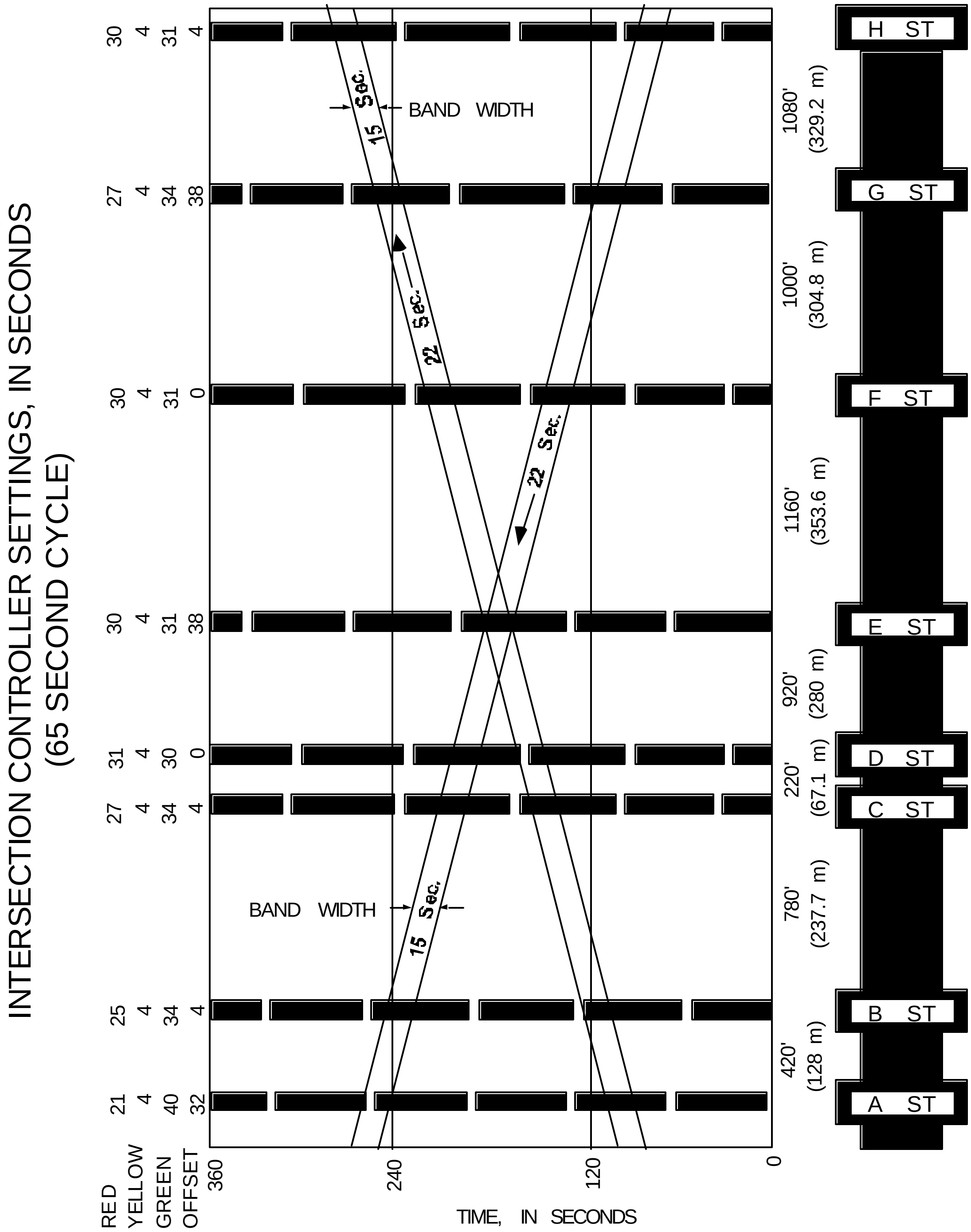


Figure 304.07-01 Time – Space Diagram

With the flexible progressive system, different timing plans may be automatically switched into effect at different times of the day. Thus, offsets, cycle lengths, and cycle divisions at each intersection may be altered independently according to a predetermined plan to suit regularly changing traffic flow patterns. The most usual arrangement on urban arterials is to provide three separate timing plans: (1) favoring inbound flow (to business districts) during the morning peak flow, (2) giving equal advantage to both directions during the off-peak hours, and (3) favoring outbound flow during the afternoon peak flow period. Setting up plans 1 and 3 is much easier than determining plan 2. The first and third plans may be set up by providing offsets in the favored direction to produce the desired speed, letting the timing for the opposing direction be determined accordingly. The timing for equal advantage in both directions requires different combinations of offsets to produce through-bands in both directions of approximately equal slope (speed) and width. Usually the minimum cycle length is determined, on the basis of the requirements of the one or two heaviest traveled intersections' cycle splits at each location determined on the basis of traffic volumes, and then different plans of offsets tried on a time-space diagram until one is found that gives proper through-bands. This may necessitate lengthening the cycle length and altering cycle splits somewhat to produce the desired through-bands.

The length in seconds of the minimum width of the through-band divided by the cycle length, expressed as a percentage, is the efficiency of the timing plan. While it is desirable to have efficiencies ranging between 40 to 50 percent, that frequently is not possible and efficiencies from 25 to 45 percent must be tolerated. Those lower efficiencies, however, often fall short of the traffic demand, particularly in central areas. As a result, there is severe disruption of progressive traffic flow and more than one wait for signal changes becomes necessary until a surge of traffic is dissipated. Conditions of that type, however, are indicative of an excess in demand over capacity in an area and can only be rectified by providing additional street capacity. No amount of cycle split adjustment can overcome supersaturated traffic conditions. Progressive traffic systems are sensitive to overloading and their timing structure shatters as soon as a few more vehicles are present per cycle than the green interval can dispatch.

304.08 PasserII-90 Model. The Progression Analysis and Signal System Evaluation Routine (PASSER) is an optimization model for progression along an arterial street considering various multiphase sequences. Further improvements in the processing algorithms and measures of effectiveness have been made by the Texas Transportation Institute, and the current version of the model is known as PASSERII-90.

PASSERII-90 seeks to maximize arterial two-way progression and minimize signal delay by pursuing a series of arterial signal timing optimization processes. Signal timings are calculated to minimize the individual intersection delay based on traffic volumes, saturation flows, and minimum phase times for a given cycle length range. PASSERII-90 can optimize signal phasings ranging from two-phase operations to multiphase, variable sequence operations.

In addition to the basic "Protected" or "Permitted" left-turn phasing, PASSERII-90 can further analyze the complicated permitted/protected or protected/permitted "Combined Phase" left-turn sequences. Maximum progression efficiency is calculated for the arterial system, given travel speeds and link distances. Optimal phase sequence, phase split timing, and coordinated offsets for each intersection are provided in the solution.

Also provided, as requested by the users, is the optimal time-space diagram. Up to 20 signalized intersections can be included in one arterial progressive system. Signal phasing is described on a "Permitted" or "Allowed" phase movement basis. Up to four possible arterial phasing sequences are allowed at any one intersection. Each cross street can have one of these four-signal phase sequences.

A range of cycle lengths can be examined for the optimal progression operation in any one run. PASSER will select the cycle length that can provide the maximum progression efficiency. That is, the program will select the cycle that provides the largest percentage of the cycle for arterial progression. Delay-minimization guidelines are provided as program output for selecting a narrow range of cycle lengths that will yield delay-efficient solutions.

Lastly, the program automatically fine-tunes the coordinated progression offsets to further minimize delay to the arrival patterns of the arterial traffic flow. This system-offset, fine-tuning algorithm will typically result in a further reduction of 5-15 percent in delay to the arterial's progressive movements. This system delay reduction is accomplished through the offset fine-tuning algorithm without any loss of arterial progression.

The program can develop the time-space diagrams that provide one-way progression in either or both directions along the arterial street. Also, PASSER may be used as a traffic planning or capacity analysis tool if volumes, saturation flows, intersection geometrics, and existing signal timings are known. This is because up to a maximum of 20 "isolated" intersections instead of 20 coordinated intersections can be "timed" and "evaluated" simultaneously if desired.

PASSERII-90 provides an exceptional list of output features. The output is headed by an echo listing of the system-embedded data, the coded input data structured around arterial system parameters, and the intersection variables. The output of the optimized solution provides a listing of the optimal timings for the arterial street, optimal signal timing plans for each intersection, a series of level-of-service evaluations for each phase, the signal controller phase interval setting report, an optimal time-space diagram, and the optional packed data array debug printouts. The implementation of the optimal signal timings is greatly aided by the provision of a complete set of phase interval tables with respect to the system master intersection. This is a system programming feature for applications on the microprocessor-based, traffic-actuated signal equipment.

304.09 PasserIII-88 Model. PASSERIII-88 is a practical computer program designed to assist transportation engineering professionals in the analysis of pre-timed or traffic-responsive, fixed-sequence signalized diamond interchanges. The program can evaluate existing or proposed signalization strategies, determine signalization strategies that minimize the average delay per vehicle, and calculate signal timing plans for interconnecting a series of interchanges along continuous, one-way frontage roads. In addition, the program can evaluate the effectiveness of various geometric design alternatives, e.g., lane configurations, U-turn lanes, and channelization. Use of the program will result in improved interchange geometrics and timing plans to substantially reduce delay costs at signalized diamond interchanges.

304.10 TRANSYT-7F Model. The Traffic Network Study Tool (TRANSYT) is one of the most widely used models in the United States and in Europe for signal network timing design. It was developed in 1968 by Robertson of the Transport and Road Research Laboratory (TRRL) in England, and since then, the TRRL has released several versions of this model. The version that is discussed here is TRANSYT-7F, where "7" denotes the seventh TRRL version of TRANSYT and "F" symbolizes that this is the Federal Highway Administration's version of TRANSYT-7 that uses North American nomenclature on input and output. The most current release of TRRL's

TRANSYT is TRANSYT-9 and the most current release of FHWA's version is TRANSYT-7F release 6.

TRANSYT-7F is used to optimize signal timing on coordinated arterials and grid networks.

The structure of TRANSYT-7F consists of two main parts:

- Design Analysis. A macroscopic, deterministic traffic flow model that is used to compute the value of a specified performance index for a given signal network and a given set of signal timings. The performance index is a linear combination of measures of effectiveness (delays and stops) that are specified by the user.

- Operational Analysis. A hill-climbing optimization procedure that makes changes to signal timings (splits and offsets) and determines whether or not the performance index is improved.

Input data for TRANSYT includes:

- Signal spacing
- Cycle length ranges
- Link speeds
- Lane configurations
- Minimum phase timings
- Phase sequencing
- Mid-block volume inputs
- Saturation flow rates
- Left-turn treatment

TRANSYT-7F has a number of options that can be controlled by the user. These options include the following:

- Buses can be modeled separately by including bus links. These can either be separate lanes or shared lanes.

- Right-turn and left-turn delays caused by pedestrians can be reflected.

- Overlap signal movements can be modeled.

- Large networks can be subdivided into sections that can be handled by the program (i.e., 50 nodes and 250 links). The boundary nodes can be fixed from section to section so that their timings are not changed in the subsequent analysis. Another alternative is the expansion of program dimensional arrays to accommodate the larger networks.

- Protected-only, protected-permissive, and permitted-only left turns can be modeled.

- Unsignalized intersections controlled by stop signs on the cross streets as well as bottlenecks can be modeled.

- Links can be prioritized to encourage development of a progression oriented solution for arterial streets.

- An estimate of network fuel consumption can be computer based on total travel, stops, and delay. The fuel consumption value includes fuel consumed at cruise, idle, and acceleration or deceleration. Fuel consumption estimates are calculated for each link and then summed for the entire network or for individual routes.

The TRANSYT-7F model is written in FORTRAN IV for 16- or 32-bit computers and is available for MS-DOS-based microcomputers. Data input management programs, most notably EZ-TRANSYT and the T7FDIM program, exist to simplify the tedious data input process. A comprehensive user's manual was written to serve as an instructional guide for traffic engineers who desire to use the model.

304.11 Arterial Analysis Package (AAPEX). The Arterial Analysis Package (AAPEX) has been developed as a tool for timing traffic signals in arterial street systems. It gathers together the design and analysis methods that have been used successfully by traffic engineers. It provides a framework for solving arterial system problems using commonly available traffic engineering data.

The AAPEX provides the use of a common database for input to other computer analysis packages. There is no need to reformat data so that these selected analysis programs can be run individually. The AAPEX system will provide the data package to operate the following analysis systems:

A. PASSERII Methodology - Bandwidth Optimization
B. TRANSYT-7F - Stops and Delay Optimization

SECTION 305.00 - PHASING CONSIDERATIONS

305.01 General. It is through the phasing and sequencing of the intersection that the principal goals for the signal installation are implemented. The phasing and sequencing of a traffic signal affect both the safety with which the intersection operates and the efficiency of movement provided to the motorists and pedestrians. It is the traffic engineer's ability to merge and balance these two often competing aspects of intersection operation that determines the success of a signalized intersection, especially in the eyes of the public. Far too many signalized intersections have been unsuccessful because the traffic engineer failed to achieve this blend, usually as a result of one or more arbitrary policies that were used to substitute for good traffic engineering.

There are several principles that the traffic signal designer will do well to remember:

- In general, the fewer the phases a traffic signal has, the better overall traffic service it will provide.

- More phases require longer cycles in coordinated systems.

- In general, more phases result in an overall reduction in intersection capacity, especially if the added phases provide totally protected left turns.

- While protected turn phases may be required to reduce the incidence of certain types of accidents, their use may result in an increase in other types of accidents.

- Where protected left-turn phases may be required, the use of protected/permissive left-turn phasing should be considered.

- Design the signal controller for the future requirements but only implement those phasing requirements needed to accommodate traffic needs.

- To the extent possible, the motorist should be left to his own recognizance. Don't make every decision for him.

This section of the manual discusses selected phasing and sequencing considerations that should aid the traffic signal designer in arriving at signal operations that maximize their service to the public. The considerations are segregated into those applicable to vehicle traffic and those germane to pedestrians.

The District Traffic Engineer should prepare and submit a signal phasing and timing plan in the following cases:

- New Signal Design - As a part of the signal preliminary and final design information for the signal project.

- Signal Modification - At any time a signal is being modified, the signal phasing and timing (existing and proposed) shall be submitted with reasons for revisions.

- Operational Improvements - Operational reviews of traffic signal installations will usually result in some timing modifications. These timing revisions should be submitted to the Headquarters Traffic Section with reasons for revisions.

The Headquarters Traffic Section will review and approve all signal phasing and timing plans before programming these changes in the controller settings. When these changes are made at the intersection, they shall also be noted in the signal inventory system.

305.02 Signal Phasing. The basic and initial phasing for a traffic signal should be a two-phase operation wherein the main street utilizes one phase and the minor street utilizes the other phase for all traffic maneuvers from those street approaches. The number of phases increases as left-turn movements are provided separate protected signal indications to a full eight-phase controller. The following sections address the advantages and disadvantages of various methods of determining special phasing considerations, including guidelines for phasing decisions. However, these special phasings should be used only when they are required to adequately handle the intersection traffic and lesser phasing arrangements have proven unsatisfactory. Typical signal phasing schematics are illustrated in Figures 305.02-01 through 305.02-03.

The general rule is "the fewer the phases, the better!" Two phases do the most efficient job of assigning the right-of-way and leave the motorist and the pedestrian on their own recognizance from there. As jurisdictions widen streets, they sometimes replace perfectly good two-phase signals with five- and eight-phase signals before they are needed. This has resulted in untold amounts of unnecessary delay to both motorists and pedestrians. There are, of course, proper applications for left-turn phases, but they should not be over used or applied in advance of the actual need for them. It may indeed be wise to install control equipment with multiphase capability in anticipation of its need, but the application of that capability should await the development of the need.

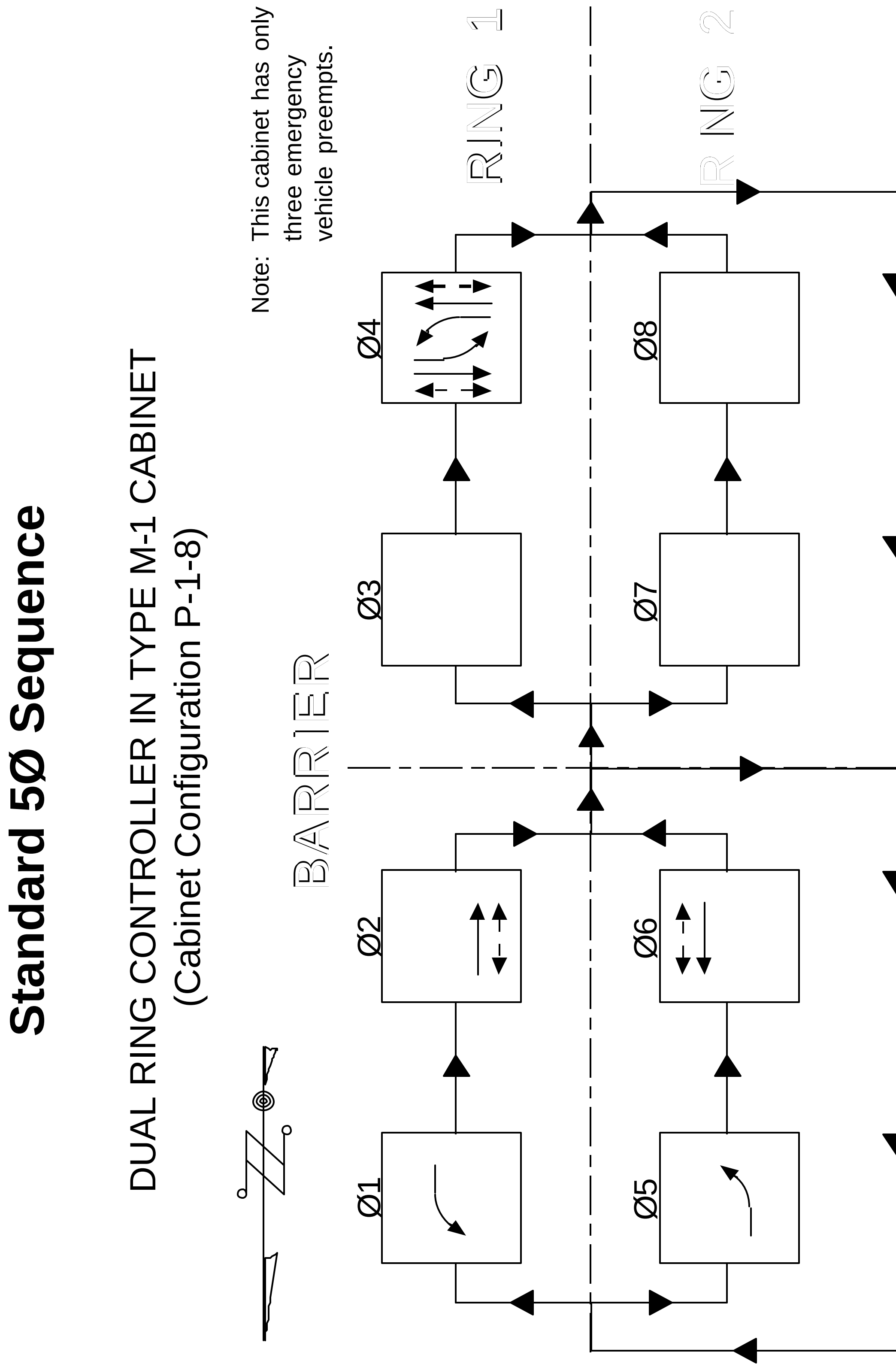


Figure 305.02-01 Standard 50 Sequence

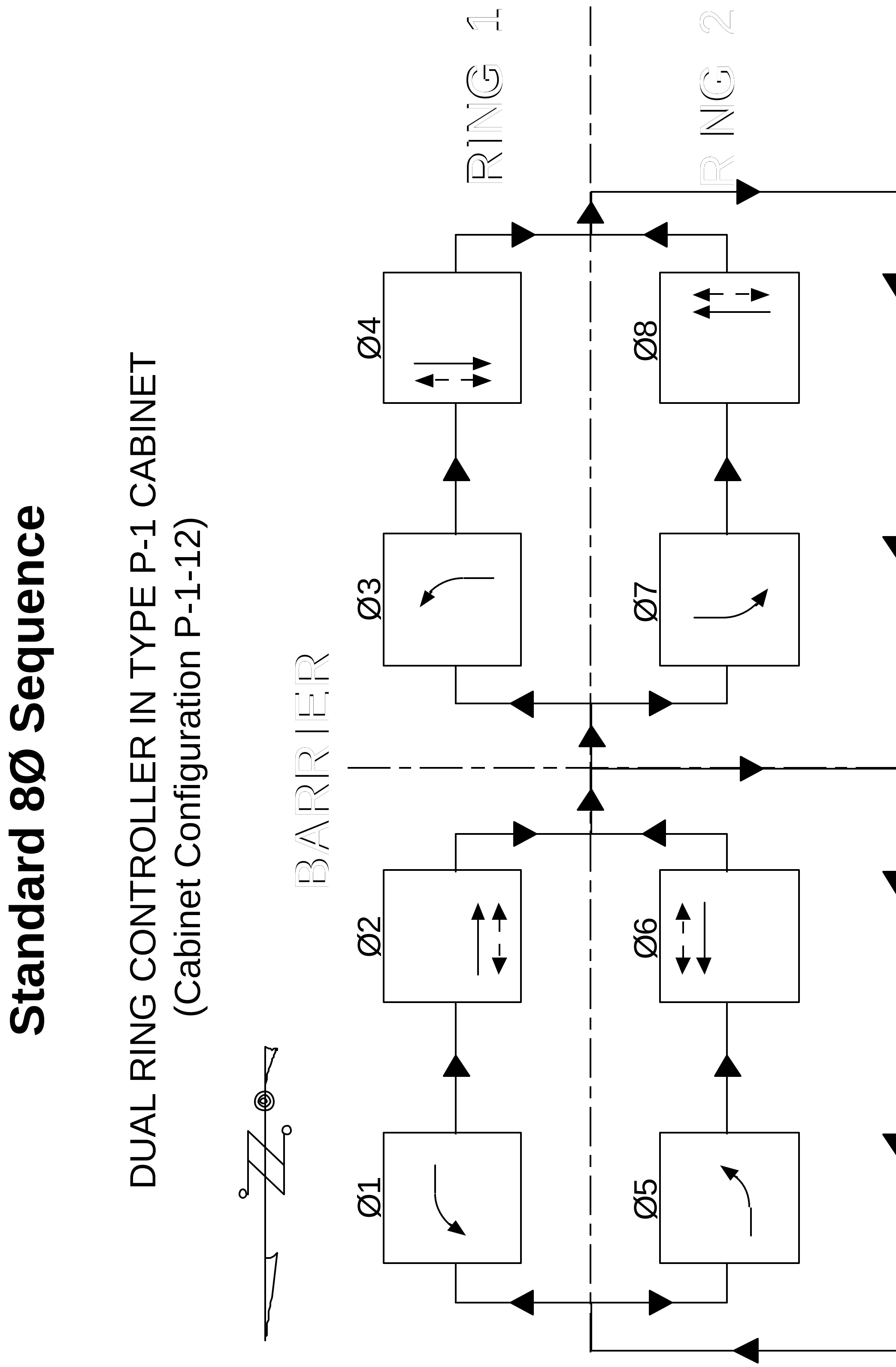


Figure 305.02-02 Standard 80 Sequence

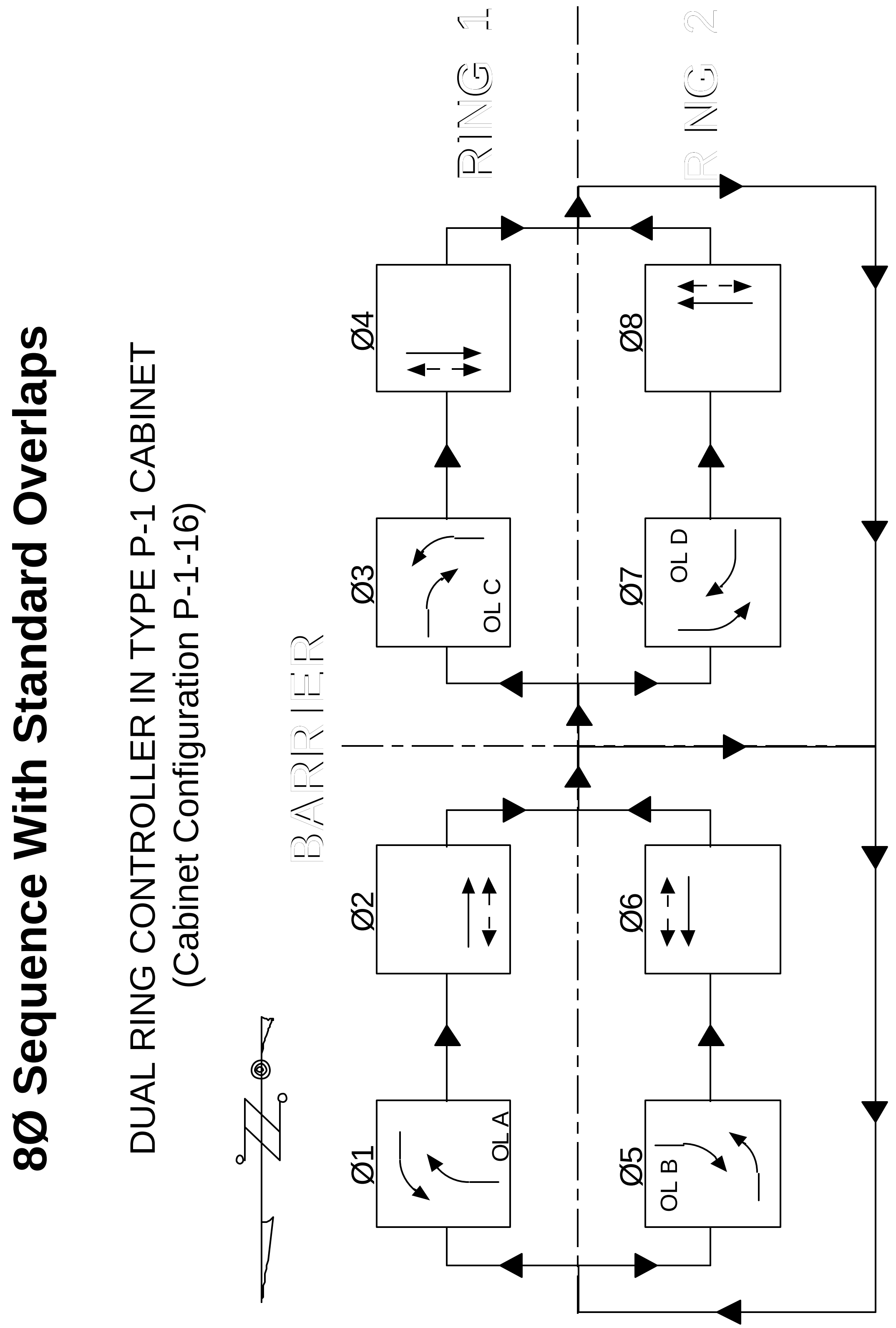


Figure 305.02-03 **80 Sequence With Standard Overlaps**

305.03 All-Red Clearance Interval. In designing an intersection's control sequence, it is wise to design in an all-red clearance interval after each phase. Control equipment should always be ordered with fully omittable all-red intervals on each phase so that they are available if needed. If not needed initially, they can then simply be turned off. All controllers now have all-reds as a standard feature in their manufacture.

305.04 Left-Turn Phasing. There are many intersections where left-turn phasing should be utilized on one or both streets in order to increase intersection capacity, alleviate or prevent a real accident problem, or both. The following philosophies apply.

305.04.01 Warrants for Left-Turn Phases. Researchers at the Center for Transportation Research of the University of Texas have developed a procedure for calculating whether or not the protection of a left-turn movement can be avoided. This procedure is documented in Figure 305.04-01.

There are two other factors that should be evaluated with regard to the need for left-turn phasing: left-turn accident history and visibility available to left-turn motorists.

If a particular left-turn movement has experienced five or more collisions with the opposing through traffic during each of the most recent three years and there is no other practical way to reduce the hazard, a fully protected left-turn phase should be considered for that movement. Often, however, protected/permissive operation will be adequate to reduce the hazard.

If the visibility available to left-turn motorists is less than adequate to permit a safe maneuver and the condition cannot be reasonably corrected, a fully protected left-turn phase should be used for that movement. A common situation resulting in poor left-turn sight distance is that of wide medians that have not been properly designed with regard to left turns. The design causes the left-turn traffic from one direction to block the visibility of the left-turn traffic from the other direction. There is generally no good reason for such a design to be used at any signalized intersection.

A left-turn phase is not warranted if the left-turn volume to be served is less than or equal to the critical left-turn volume (L) shown in the table below for the conditions of opposing volume (V), number of lanes for opposing traffic, the unprotected green time (G) that will be available to the left-turn traffic, and the cycle length (C) (or the ratio G/C).

Number of Opposing Lanes	Opposing Volume V (vph) adjusted by G/C	Critical Left-Turn Volume L (vph)
1	0 < V/(G/C) < 1000	764(G/C) - 0.634V
	1000 < V/(G/C) < 1350	484(G/C) - 0.348V
2	0 < V/(G/C) < 1000	855(G/C) - 0.500V
	1000 < V/(G/C) < 1350	680(G/C) - 0.353V
	1350 < V/(G/C) < 2000	390(G/C) - 0.167V
3	0 < V/(G/C) < 1000	892(G/C) - 0.448V
	1000 < V/(G/C) < 1350	735(G/C) - 0.297V
	1350 < V/(G/C) < 2400	390(G/C) - 0.112V

Source: Guidelines for Use of Left-Turn Lanes and Signal Phases, Research Report 258-1, Center for Transportation Research, University of Texas at Austin, January, 1984.

Figure 305.04-01 Warrant For Left-Turn Phases

305.04.02 Common Case of Unwarranted Left-Turn Protection. An often overlooked unwarranted use of left-turn phases occurs at intersections where a protected phase is required for one approach on a street but not for the other approach. With the current easy availability of dual-ring controllers, there is a tendency to protect left turns from both approaches, especially when protected/permissive phasing is used, even though only one requires it. This practice should be avoided. At most intersections, the through traffic is a far larger proportion of the traffic than the left turns and to display an unneeded left-turn phase, even for a short time, robs this through traffic of valuable green time. The signal designer must always remember that a paramount concern is to keep the signals green as much of the time as possible for the major movements in order to minimize the likelihood of stops and to minimize the total delay at the intersection.

305.04.03 Excessive Service to Left Turns. Good traffic engineering, other things being equal, seeks to keep the most people moving while at the same time minimizing unnecessary delay to other traffic. Many traffic signal designers forget that left-turn traffic, while very significant at many locations, is still a minor movement at the intersection. Hence, they exert great diligence in giving the left-turn phases an inordinate level of service at the expense of the through traffic. This error is most prevalent at isolated intersections. The designer wants the signal to respond quickly to fluctuating traffic, especially under lighter traffic conditions, so he times the signal to quickly jump from one phase to the next in response to the detector activity. While this is good to a point, it tends always to provide an extremely high level of service to the minor movements, while requiring virtually all major phase traffic to stop.

305.04.04 Protected/Permissive Phasing Versus Fully Protected Phasing. In general, when left-turn phases are installed at an intersection, protected/ permissive phasing should be considered. With this type of phasing, the left-turn traffic is given protected phase during a portion of the cycle, but is also allowed to move during the through-traffic phase. Protected/permissive phasing has two advantages over totally protected phasing. First, it increases the intersection's capacity, and will often allow the protected left-turn phase to be skipped. Second, and more importantly, it is more acceptable in the eyes of most motorists because it leaves the decision of whether or not to proceed in the unprotected interval up to them. Nothing is more aggravating to a motorist than to wait for a fully protected left-turn phase when there is no opposing through traffic or when there are adequate gaps in the opposing through traffic. Such a condition breeds flagrant violation of the protected left-turn phasing.

There are, of course, times when left-turn traffic should be fully protected. If the left-turn phasing is installed as a result of a documented left-turn accident problem, full protection should generally be used.

Often, however, it is possible to isolate the problem to certain periods, such as the peak traffic hours. In such cases, it may be wise to allow permissive operation during most of the day, while locking it out during the problem periods.

Other situations that may require full protection of left turns are when dual left-turn lanes are used and situations in which the view of oncoming through traffic is blocked. This latter situation is often the case when there is a significant offset in the left-turn bays on a street with considerable left-turn traffic.

In the absence of any of these conditions or the <u>reasonable</u> expectation of accidents, protected/permissive phasing should be tried prior to installing fully protected phasing.

Queue detector zones, front detector delays or detector switching should be considered to most efficiently control the protected mode of the Protected/Permissive movement.

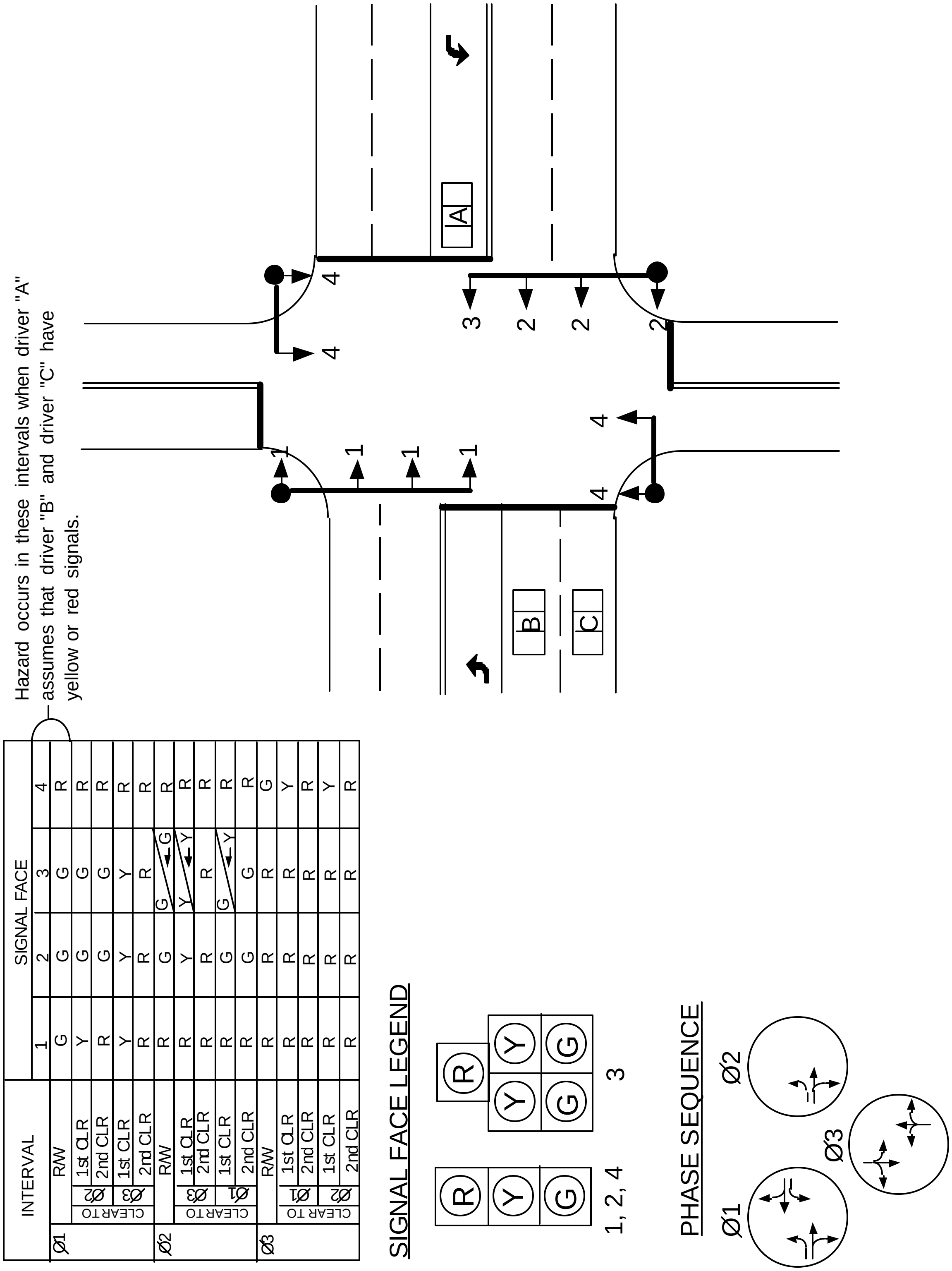
With regard to the anticipation of left-turn problems, overprotection is commonly encountered when a new traffic signal is installed on a multilane roadway or when a roadway is widened at an existing signalized intersection. The rationale is either a fully protected left-turn phase will ultimately be needed, so it should be implemented initially to reduce costs, or a protected left-turn phase is needed to prevent left-turn accidents that are a result of the number of the opposing traffic lanes. Left-turn problems can be correctly anticipated by good traffic engineering, but full protection before it is actually warranted should be avoided. The benefit to the motoring public will outweigh the added cost of changing the operation one or two years after an improvement is implemented. If properly designed in the first place, the cost of such changes can be minimized. In the case of the concern over the number of opposing traffic lanes, unprotected left turns can generally take place safely across two opposing through lanes or two opposing through lanes with a right-turn lane. There is legitimate concern about allowing permissive left turns when there are three or more opposing through-traffic lanes. The problem in such cases is not the shear magnitude of the through-traffic volume, but rather the fact that there is sufficient through traffic to often effectively block the left-turn driver's view of oncoming cars in the curb lane, a condition that can lead to serious collisions. It is probably not wise to allow permissive left turns when there are four or more lanes; however, with three lanes, permissive left-turn movements can often be safely allowed during light traffic periods, with full protection being provided during other times. (NOTE: For the purpose of evaluating the need for a protected left-turn movement, opposing right-turn traffic should be considered as opposing traffic unless it is controlled either by a physical island or a painted island that is large enough to be recognized by the left-turn motorists.)

305.04.05 Left-Turn Phasing at T-Intersections and at Intersections of Two-Way and One-Way Streets. When left-turn protection is needed at a T-intersection, it is generally best to use lagging left-turn phasing rather than leading left-turn phasing, unless leading phasing would better serve the needs of progressed traffic movement. The same holds true where a left-turn phase is needed at the intersection of a two-way street and a one-way street. The reason for this is that lagging phasing allows the left-turn traffic to queue up and to be dispersed efficiently once it receives the right-of-way. Of course, there must be adequate left-turn storage for this queuing so that the traffic waiting to turn left will not block the through traffic. If protected/permissive phasing is utilized, a further significant benefit accrues if presence detection, combined with non-locking controller memory, is also used. In such cases, because left turns are allowed during the through-traffic phase, the left-turn queues will often be shorter at the inception of the protected phase, resulting in shorter left-turn phases. During light to moderate traffic, it is common to skip the left-turn phase entirely because all of the left-turn traffic clears during the through-traffic phase.

305.04.06 Caution Necessary in Using Lagging Left-Turn Phasing. There is a danger in the indiscriminate use of protected/permissive left-turn phases that lag in one direction of travel. This situation is illustrated in Figure 305.04.06-01.

The hazard is to the motorist who may be attempting to make an unprotected left turn at the moment when the through-traffic phase terminates. This may be the case of motorist “A,” who is attempting to turn left when the signal is displaying the first or second clearance from phase A to phase B. The unsafe situation occurs when motorist “A” observes the yellow or red indication in signal face 1 and assumes that motorists “B” and “C” are also receiving such indications and will stop. Under this incorrect assumption, motorist “A” begins the left turn and collides with one of the oncoming cars, that was moving correctly under the green indications of both signal faces 2 and 3.

There are three possible solutions to this dilemma. The lagging phase should be replaced by a leading phase, the left-turn movement opposite the lagging phase could be made fully protected, or the phasing could be changed to provide lagging protected/ permissive phasing for the left turns on both approaches at the same time. In the latter case, care must be taken to ensure that the through-traffic phase terminates for both directions at the same time; otherwise, the hazardous situation can still exist.



INTERVAL			SIGNAL FACE 1	2	3	4
Ø1		R/W	G	G	G	R
	CLEAR TO Ø2	1st CLR	Y	G	G	R
		2nd CLR	R	G	G	R
	CLEAR TO Ø3	1st CLR	Y	Y	Y	R
		2nd CLR	R	R	R	R
Ø2		R/W	R	G	G / ← G	R
	CLEAR TO Ø3	1st CLR	R	Y	Y / ← Y	R
		2nd CLR	R	R	R	R
	CLEAR TO Ø1	1st CLR	R	G	G / ← Y	R
		2nd CLR	R	G	G	R
Ø3		R/W	R	R	R	G
	CLEAR TO Ø1	1st CLR	R	R	R	Y
		2nd CLR	R	R	R	R
	CLEAR TO Ø2	1st CLR	R	R	R	Y
		2nd CLR	R	R	R	R

Figure 305.04.06-01 **Potential Hazard In The Use Of Protected/Permitted Phasing For Lagging Left Turns**

305.04.07 Lead-Lag Left-Turn Phasing for Improved Signal Coordination. At intersections that require that protected left turns be accommodated on both approaches of a coordinated street, it is often useful to operate the intersection with one left-turn phase leading the through-traffic phase and the other left-turn phase lagging it in order to maximize the potential for progressed two-way traffic movement on the street. Many systems and controllers have the ability to switch the leading and lagging phases depending on the needs of the current timing plan. This capability is referred to as phase rotation. Such use of the sequencing capabilities of the equipment is good stewardship of the green time available; however, the caution noted in Section 305.4.6 regarding lagging left-turn phases should be kept in mind. Furthermore, depending on expected queue arrival time for the lagging phase, it may be necessary to artificially extend the phase to its maximum to ensure achievement of the progressed movement.

305.05 Split Phasing. An undesirable phasing technique is serving a street, usually a side street, one approach at a time or a split phase for the side street. The reason for this is generally that traffic from the two approaches would otherwise need to occupy the same space at the same time, an obvious problem, or where street width does not provide adequate space for a left-turn lane. Unless the left-turn traffic is equal to or greater than the through traffic, this split phasing is very inefficient and other alternatives, including geometric improvements should be sought. Such phasing also makes the associated pedestrian service very inefficient when pedestrian activity is constant on both associated crosswalks. It should be noted that this is essentially a three-phase or more operation that steals green time away from the major street.

305.06 Right-Turn Phasing. At the majority of signalized intersections, no special phasing is needed for right-turn traffic, as Idaho Code section 49-802.3(b) authorizes "right-turn-on-red". There are occasions when special treatment of right turns in a signal's sequence is appropriate. Generally, these would involve high-volume (300 vehicles per hour or more) movements where the right turns had one or more exclusive lanes available to them. In such cases, if the intersection's phasing provided a protected phase for the left turns from the approach to the right of the movement in question, a right-turn overlap with the left-turn phase could be provided.

305.07 Diamond Interchange Control. The problem of the proper control of diamond interchanges arises because of the closeness of the two intersections involved and the magnitude of the traffic on each ramp that desires to turn left. This phenomenon creates a situation in which the roadway between the ramps often becomes saturated and the resulting congestion causes traffic back-ups. Furthermore, diamond interchange signalization often requires ramp traffic to stop both on the ramp and at the far-side signal. For diamond interchanges, whether isolated or in a coordinated system, the use of two coordinated controllers, one for each ramp intersection, is required.

The same good rule of minimizing the number of phases at each intersection will usually provide the best answer. Do not be afraid to require some movements to stop at the second signal if this is best when considering all movements.

305.08 Skip-ability Restrictions. Most actuated controllers available today permit full skip-ability of unneeded phases based on lack of detector activity during the cycle; that is, they can omit service to any and all phases on which there have not been calls during the previous cycle. This is an excellent feature that is freely utilized in most applications. There are cases, however, where this skip-ability should be selectively restricted in order to better serve traffic. The most common such case is in a coordinated system, where the major street's through-traffic phases are operated in a semi-actuated mode to ensure that they are called every cycle for the benefit of coordination. There are also two other applications of restricted phase skipping with regard to vehicle traffic that should be mentioned. The first was mentioned earlier under the caution about the use of lagging phasing. The second involves the idea of maximizing the potential for the major street's through traffic to receive a green signal.

At most intersections, one of the streets will have a preponderance of the traffic, to the point that it would be rare even under light traffic conditions to skip the through-traffic phase. Under such conditions, there is little to be gained, and considerable efficiency to be lost, from setting up the controller for full skip-ability. The result of such a setup would be that the controller would often dwell on some phase other than the major street's through-traffic phase, causing that traffic which ought to be favored to have to slow down and often stop while the signal changes phases. This can be avoided by simply operating the signal in a manner that recalls the controller to the major street's through-traffic phase in the absence of activity on the other phases. Such action will greatly increase the probability of that traffic having a green signal as it approaches the intersection, while not unduly causing delay on the other phases.

305.09 Dual-Entry On Dual-Ring Controllers. Most dual-ring actuated controllers available today allow selection of either single-entry operation or dual-entry operation. In single-entry operation, during light traffic with detector activity on only one phase, the controller will display green to only the phase on which there is currently activity or on which there was last activity. All other phases will display red. Dual-entry operations by comparison, will display green not only to the active phase, but also to a complementary (non-conflicting) phase. In keeping with the idea expressed previously of maximizing the potential for traffic to arrive with a green signal, dual-entry is generally better. Furthermore, most such controllers allow two modes of dual-entry operation. In one mode, the complementary phase displayed can be any non-conflicting phase. In the other mode, the complementary phase must be the complementary through-traffic phase. Obviously, in light of the previous discussion, this latter option is the better of the two because it ensures that the green is displayed to the higher volume phases, thus further improving the potential for the signal to be ready to receive approaching traffic.

The dual-ring controller is separated by a compatibility line so that any two phases on one side of the compatibility line or in separate rings can be timed concurrently. Any two phases on opposite sides of the barrier or in the same ring cannot be active simultaneously. Therefore, there must be phase association with each ring to prohibit conflicting signal phases being active concurrently. Normally, the intersection phasing is established so one ring responds to the main street signal phasing and the other ring responds to the side street phasing. However, special sequence timing configurations are available to modify the compatibility line and fully utilize the dual ring applications for special signal phasing applications.

305.10 Pedestrian Phasing Considerations. It is ITD's policy to install pedestrian signals for pedestrians crossing every leg of each signalized intersection that has curbs or sidewalks unless such crossing is prohibited by signs. Pedestrian signals should also be used at most rural-type intersections unless there are no pedestrians and very little potential for pedestrian traffic.

It must be remembered that pedestrians are not as easily controlled by traffic signals as vehicles. If a pedestrian perceives that he is being unnecessarily delayed by a traffic signal, he may simply ignore it and act on his own recognizance. Furthermore, the traffic signal designer should also remember that the pedestrian's time is just as valuable as that of a motorist. In view of this, the designer should make every reasonable effort to maximize the WALK time that is available to the pedestrian.

305.11 Preemption. It is often necessary to interrupt the normal operation of a traffic signal or a group of traffic signals in order to facilitate the clearance of traffic that might be backed up onto an active railroad track or to facilitate the movement of emergency vehicles. The preemption capabilities are built into most signal controllers requiring only external actuation and reprogramming for implementation.

The typical operational mode for signal preemption would be as follows:

a. On preemption actuation, provide a clearance interval for active green indications.

b. Respond to preemption phase, i.e., intersection approach with railroad grade crossing, with adequate time to clear traffic.

c. Lock signal phasing into phases that will prohibit any traffic accessing the preempted approach.

d. After preemption clearance, respond to the preempted approach and other phases to clear traffic delayed during the preemption phasing.

Guidelines for railroad preemption are addressed in Section 8C-6, MUTCD, and the Traffic Control Devices Handbook.

Where emergency vehicle route preemption is needed, local preemption must be used for each intersection. Such preemption should not be entered into on a wholesale basis. At most intersections, little benefit will accrue over the normal use of sirens and lights. As with any other aspect of traffic control, the benefits should outweigh the disadvantages before preemption is installed at an intersection. It is further recommended that preemption be installed with planned routes in mind. The cost and complexity of the equipment relationships both increase dramatically when an attempt is made to permit preemption of signals from any possible direction.

Installation and maintenance of emergency vehicle preemption equipment in conjunction with traffic control signals on the state highway system shall be covered in an agreement between the state and local public agency. The following policy for state participation shall be followed in new agreements and used to modify old agreements where applicable.

- The state will:
  - Approve preemption signal phasing
  - Approve and modify controller equipment within the traffic signal controller cabinet to accommodate preemption by approach.
- The city will:
  - Furnish and maintain all material and/or equipment to be installed by the city within the pre-wired controller cabinet under state supervision.
  - Furnish, install, and maintain all material and/or equipment from the emergency vehicle station to the controller cabinet.

- o Furnish, install, and maintain all material and/or equipment to provide an indication to the driver of an emergency vehicle that the controller has been successfully preempted.

305.12 Flashing Considerations. There are two reasons for flashing a traffic signal: to reduce the level of control when traffic volume is low (nighttime flash) and to provide a safe method of control when the signal is inoperative (emergency flash).

All signals facing a given approach should flash the same color, except as noted in MUTCD 4B-6, paragraph 8(b). All signals facing a given approach should also generally be connected to the same circuit of the flasher so that they flash simultaneously.

305.12.01 Nighttime Flash. While a traffic signal may be needed at an intersection during much of the day, it is often the case that the signal is not needed all of the time. Consideration should be given to operate the signal in flashing mode. A number of warrants have been developed for determining when to place a signal into flashing operation. Engineering judgment may also be used. The following factors should be considered:

- Traffic volumes during the period when the signal is to be flashed to ensure there are adequate gaps for the cross street traffic to safely enter the intersection.

- The crash history of the intersection.

- The reasons for the signal's initial installation. The ratio between major and minor street volumes.

- The visibility for side street traffic.

- The distraction and glare generated by a flashing signal (especially the amber indication).

If it is decided to flash the signal, the times of flashing operation should be the same as for other signals in the area so as not to violate motorists' expectations. In general, it is not a good practice to switch back and forth between flashing and stop-and-go operation during the daytime, though there may be cases where this is appropriate.

305.12.02 Emergency Flash. In general, when a signal is operated in the flashing mode, it is most efficient for traffic if the major street through movements are flashed yellow and all other movements are flashed red. In some instances, it may be appropriate to flash all movements red. This is typically done at locations where major street flow is so heavy that few gaps exist for crossing traffic, or where sight distance problems make it hazardous to operate the intersection on a see-and-be-seen basis, as noted in Chapter IX of the AASHTO "Green Book." However, whenever it can be safely accomplished, flashing yellow should be used so that at least half of the traffic will not have to stop unnecessarily.

The nighttime flash mode should be initiated at the end of the common major street red interval which is programmed into the controller timing. The flashing indications noted above for approaches, left-turn movement, and pedestrian signals are also applicable for maintenance operations. Sections 4B-5, paragraph 4, and 4B-6, paragraph 8, MUTCD, outline the specific requirements for signal flashing operations.

SECTION 306.00 - TIMING GUIDELINES

306.01 General. Once the signal phasing for an intersection has been determined, the timing of the various intervals of the signal and of the relationship of the signal to those at other intersections must be developed. It is this timing that will determine whether the intersection will function to the public's advantage or disadvantage. Therefore, it is necessary to clearly understand the objectives to be achieved for each different type of operation so that the public will be well served. This section of the manual addresses these concerns.

It is ITD policy that traffic signal timings shall be approved only by the district traffic engineers. Any changes that the traffic signal maintenance staff must make in the timings to render an intersection safe while repairs are pending shall be immediately reported to the district traffic engineer. Upon repair of the equipment, the original timings shall be restored, unless other timings have been provided by the traffic engineer. The advice of the traffic signal maintenance staff regarding signal timing is valuable and is encouraged; however, because traffic signal timing has a direct effect on the safety of the public, all timing must be the responsibility of an engineer.

306.02 Vehicle Signal Change Interval. A vehicle signal change interval is that period of time in a traffic signal cycle between conflicting green intervals. It is the time required to terminate one green indication before initiating a conflicting green indication characterized by either a yellow interval or a yellow and all-red interval. At the present time, there is considerable discussion of proper timing for change interval with no recommended national practice adopted at this time.

The Idaho Motor Vehicle Code 49-802.2 permits vehicles to enter the intersection on a yellow indication - termed as a permissive yellow rule. These vehicles have lawfully entered the intersection and accordingly are permitted to clear the intersection on the remaining yellow interval, an all-red interval, or subsequent green indication. It should also be noted that Idaho Code permits vehicles to enter the intersection on a green indication only after yielding the right-of-way to vehicles lawfully within the intersection.

However, drivers are not always that observant of vehicles entering the intersection, particularly at the far side of an intersection, that can lead to a conflict between the two vehicles.

The recommended formula for determining an appropriate change interval is:

$$Y + R = t + \frac{V}{2a \pm 2G} + \frac{W + L}{V}$$

Where:	Y	=	length of the yellow interval.
	R	=	length of the all-red interval.
	t	=	driver perception/reaction time, recommended at 1.0 seconds.
	V	=	velocity of approaching vehicle in meters/second, recommended that the 85 percentile signal approach speed or the posted speed limit, converted to meters/second, be used.
	a	=	vehicle deceleration rate, recommended as 3.1 meters (10 feet) per second^2.
	g	=	acceleration due to gravity at 32 feet (9.8 meters) per second^2.
	G	=	grade of the signal approach in percent divided by 100 or 2 percent is 0.02. A downhill grade results in a negative term, i.e., -2 Gg.
	W	=	width of intersection measured in meters from the near side stop line to the far edge of the conflicting traffic lane along the vehicle path.
	L	=	length of vehicle clearance, recommended as 20 feet (6.1 meters) for passenger cars.

The above formula will determine the total change interval composed of a yellow interval and all-red interval. The recommended minimum yellow intervals for traffic signals on the state highway system in Idaho are as follows:

Approach Speed	Standard Yellow Interval	All-Red Clearance Interval
25 mph	3.2 sec	Optional
30 mph	3.2 sec	Optional
35 mph	3.2 sec	Optional
40 mph	4.0 sec	Required
45 mph	4.0 sec	Required
50 mph	4.0 sec	Required
55 mph	4.0 sec	Required
> 55 mph	5.0 sec	Required

The all-red clearance interval is determined by computing the change interval, "Y + R," noted above and subtracting the standard yellow interval. The yellow interval has been standardized to present the drivers the same yellow interval at comparable intersections. Additional clearance time is then provided by adding an all-red interval for a longer change interval.

It should be recognized that longer change intervals detract from the available intersection green time and are only needed if there are potential vehicle or vehicle-pedestrian conflicts between signal phases. Note that the term $\frac{(W+L)}{V}$ provides additional clearance time for a vehicle to clear the intersection conflict zone. However, it is desirable to set a minimum yellow interval based on engineering judgment and then adjust the change interval using an all-red interval if needed.

An all-red interval may be desirable at an intersection to provide additional time for a vehicle to clear the intersection before there are conflicts with pedestrians or other vehicles. The need for an all-red interval must consider a number of factors as follows:

- Sight distance between vehicles or vehicle/pedestrian conflicts.
- Phasing of signal indications resulting in location of clearing vehicle versus conflicting vehicle or pedestrian movements.
- Width of intersection or length of turning path of vehicle.
- Start up delay of a conflicting pedestrian or vehicle movement plus the time to reach a point of conflict with the clearing vehicle.
- Speed of the approaching vehicle.

- Required intersection clearance for a protected left-turn movement relative to position in intersection versus conflicting pedestrians or vehicles.

- Field observation of intersection operations relative to vehicle conflicts with only a yellow interval and intersection accidents attributable to vehicle change interval.

The all-red intervals should not be less than 0.5 seconds and would normally be limited to 2.0 seconds. The determination of the all-red interval should be based on the factors noted above, calculated values, intersection observations, vehicle clearance practices at comparable intersections, and engineer judgment.

The performance of drivers at an intersection may alter the consideration of appropriate signal change intervals. At times, signal head visibility may be restricted because of background lighting, vegetation, curvilinear alignments or other vehicles. If possible, the signal visibility shall be improved in lieu of added signal change intervals. Excessive downhill roadway grades may significantly increase stopping distances or decrease the driver's desire to stop. Additional warning devices such as "signal ahead" or "prepare to stop when flashing" are usually more effective in curing a grade problem than an unduly long signal change interval. Truck speeds and deceleration rates are different than automobiles, but truck drivers normally use longer vehicle headways and are more aware of their vehicle limitations. However, it is recommended that signal installations with significant truck volumes be observed to make sure that signal change intervals are adequate for the truck operations. Roadway approaches may have surface undulations such as gutter drainage or railroad tracks that may result in lower vehicle approach speeds than indicated in the above formula so the signal change interval should be adjusted if this is the case.

306.03 Cycle Length. Cycle length is composed of the total signal time to serve all of the signal phases including the green time plus any change interval. Longer cycles will accommodate more vehicles per hour but they will also produce higher average delays.

The best way is to use the shortest practical cycle length that will serve the traffic demand. Vehicles at a signal installation do not instantaneously enter the intersection. Early studies by Greenshields found that the first vehicle had starting delay of 3.7 seconds to enter the intersection with subsequent vehicles requiring an average of 2.1 seconds each. Generally, vehicles will pass over an approach detector with a headway of 2 to 2.5 seconds. For general calculation purposes, an average time of 2.5 seconds per vehicle to enter the intersection is a conservative value. This value can be used to estimate signal timing for planning purposes.

The cycle length includes the green time plus the vehicle signal change interval for each phase totaled to include all signal phases. A number of methods have been used to determine cycle lengths as outlined in the Highway Capacity Manual, ITE Manual on Traffic Signal Design, and ITE Transportation and Traffic Engineering Handbook. Webster provided the basic empirical formula that would minimize total intersection delay as follows:

$$C = \frac{1.5\,L + 5}{1.0 - \Sigma Y_I}$$

Where: C = optimum cycle length in seconds adjusted usually to the next highest 5 second interval. Cycle lengths in the range of 0.75C to 1.5C do not significantly increase delay.

L = unusable time per cycle in seconds taken as a sum of the vehicle signal change intervals.

$$\Sigma Y_i = \frac{\text{critical lane volume each phase}}{\text{saturation flow}}$$

The saturation flow will be between 1,500 and 1,800 vehicles per hour. Refer to Highway Capacity Manual. The “Y” value should be computed for each phase and totaled to arrive at ΣY_i for all phases.

Note: The traffic volumes used should be the predicted volumes at time of signal turn-on. The volumes should also be the peak hour or peak 15-minute period for the cycle determination.

When the cycle length has been determined the vehicle signal changes are deducted giving the total cycle green time that can be proportioned to each signal phase on the basis of critical lane volumes. The individual signal phase times are then the proportioned time plus the vehicle change interval on each phase.

To ensure that critical lane volumes are adequately served, a capacity check should be computed for each green interval. This can be done by making the following computations for each phase:

1. For each signal phase, determine the critical lane.
2. Then for each signal phase, determine in that critical lane the vehicles served per cycle.
3. That phase minimum green time would be as follows:

   Phase Minimum
   Green Interval = Vehicles per cycle x 1.1 x 2.1 sec + 3.7 sec

   1.1 sec provides a 10% increase for capacity traffic fluctuations
   2.1 sec is the average headway per vehicle
   3.7 sec is the time delay to start a traffic queue

4. The total cycle length equals the sum of the phase minimum green intervals determined in item no. 3.

The minimum green interval should be less than green intervals, determined above under the Webster method. If not, the cycle length should be increased with additional time allocated to those phases not meeting the capacity criteria.

306.04 Pedestrian Timing. The pedestrian timing shall be adequate for the pedestrian crossings recognizing the walking characteristics of the pedestrians using the crossing. Concurrently, the pedestrian timing interval must be coordinated with the vehicle signal phases.

For pre-timed controls it may be necessary to lengthen the companion vehicle phase so there is adequate time for the pedestrian movement. At actuated installations, pedestrian push buttons and pedestrian timing controls should guarantee adequate crossing times.

Pedestrian walking speeds of 3.5 to 4.0 fps per second (1.1 to 1.2 meters) have normally been used with a tendency to use a higher walking speed because of the impact of pedestrian timing on phase and cycle timing. However, studies of free-flowing pedestrian walking speeds range from 2.5 to 5.0 fps per second (1.1 to 1.5 meters). Specific attention should be directed towards pedestrian crossings used by the elderly that normally have a slower pace and would take longer to cross a street. The initial intersection investigation should note these pedestrian characteristics and provide information on the required pedestrian crossing times. The 3.5 to 4.0 fps per second (1.1 to 1.2 meters) walking speed can be used for pedestrian interval timing if there is no data to indicate that a slower walking speed is appropriate. A longer pedestrian timing interval is appropriate if the signal phase and cycle times permit. In all cases, the pedestrian timing should be reviewed in the field after installation to ensure that the pedestrian walking speeds and pedestrian timing intervals are adequate for the pedestrians at a specific intersection.

The pedestrian interval is composed of “WALK” and “DON’T WALK” intervals. The total pedestrian interval should provide ample time for the pedestrian to walk to the center of the far lane at the selected walking speed prior to the all-red clearance interval. A WALK interval of 4 to 7 seconds is recommended in the MUTCD to allow the pedestrian ample opportunity to leave the curb before the pedestrian clearance interval DON'T WALK is displayed. If there are very few pedestrians using a crosswalk, a minimum 4-second WALK interval is usually adequate. However, field observations in some locations have noted a pedestrian reluctance to proceed across the street if the WALK interval is very short. Again, the timing must be reviewed in the field to ensure that an adequate WALK interval is provided to obtain a satisfactory pedestrian observance of the pedestrian indications.

306.05 Detection Dilemma Zones. Traffic signal design and operation has been confronted with the driver’s dilemma zone on higher speed signal approaches. The drivers are faced with a “dilemma” on whether to stop for a yellow indication or proceed through the intersection. Detection placement and signal timing must be designed to minimize this dilemma for the drivers.

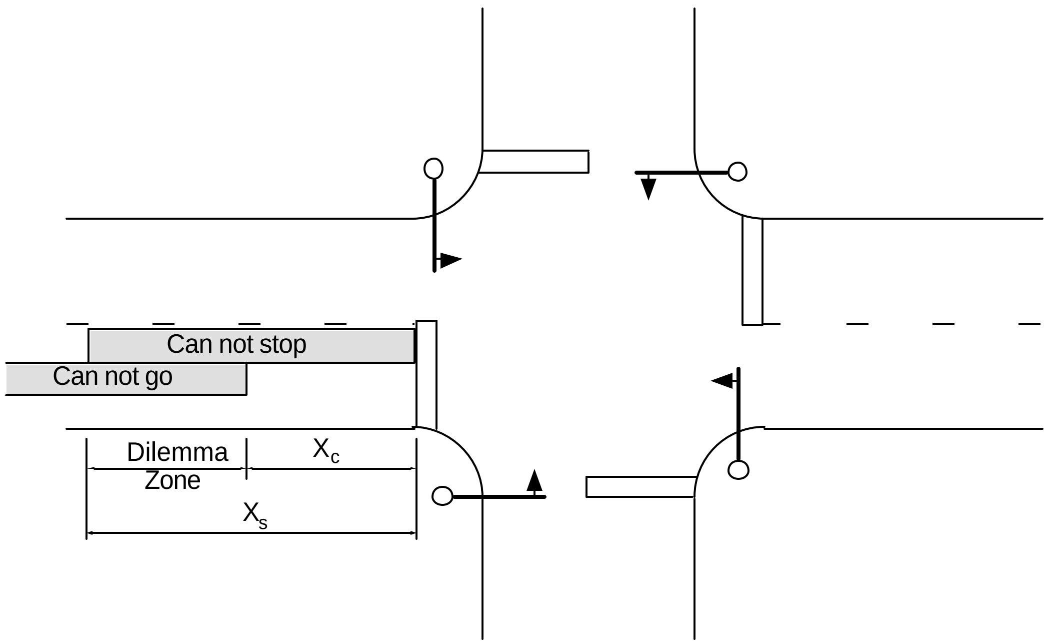
As a driver approaches a signal at a constant speed and receives a yellow indication, he is faced with a decision. He must decelerate and stop before entering the intersection or proceed and clear the intersection. The decision to stop is based on vehicle stopping distance with a 1.0-second reaction time and deceleration rate of 10 feet (3.1 meters)/second^2. These distances (Xs) are computed for various speeds and illustrated in Figure 306.05-01. At any given speed the Xs distance is the minimum distance from the approach stop line that will permit the driver to stop on a yellow indication.

If the driver decides to go through the intersection on yellow, then he must be closer to the stop line than Xc in Figure 306.05-01. The dilemma zone is the difference between the stopping distance Xs and the clearance distance Xc as indicated in the table. Where the clearance distance equals or exceeds the stopping distance, the driver has an option of either stopping or proceeding and he can do either safely. As indicated in the table, the dilemma zone does not exist on lower speed signal approaches. Also, the dilemma zone can be reduced by increasing the yellow clearance interval. However, familiar drivers readily recognize a longer clearance interval and begin to treat the yellow as an extended green, nullifying the purpose of the yellow indication.

Therefore, it is desirable to limit the yellow indication and use an all-red indication. Accordingly, ITD has standardized yellow clearance intervals as noted in section 306.02.

ITD uses a multiple loop detection design with presence loops near the stop line. A combination of loop spacing and signal passage time from the farthest loop to the stop bar essentially eliminates the dilemma zone. If the driver activates the first loop prior to a yellow interval they are provided green time to the intersection except when that cycle terminates because of maximum green.

Also, if the driver decelerates below a 15 percentile speed, his passage time between detectors exceeds the timed passage time, with the signal reverting to yellow indication. Slowing to this lower speed does not create a dilemma zone so the driver is able to stop at the stop line. The recommended loop layouts for various signal approach speeds are shown in Figure 306.05-02.



Driver Dilemma Zone At Various Speeds And Yellow Intervals

Vehicle Speed (mph)	Stopping Distance "X_S" ft (m)	Clearance Distance "X_C" Ft (m) at Yellow Interval of			Dilemma Zone Ft (m) at Yellow Interval of		
		3.2 sec	4.0 sec	5.0 sec	3.2 sec	4.0 sec	5.0 sec
20	73 (22.3)	65 (19.8)	88 (26.8)	117 (35.7)	8 (2.4)	—	—
25	104 (31.7)	81 (24.7)	110 (33.5)	147 (44.8)	23 (7.0)	—	—
30	141 (43.0)	97 (29.6)	132 (40.2)	176 (53.6)	44 (13.4)	9 (2.7)	—
35	184 (56.1)	113 (34.4)	154 (46.9)	205 (62.5)	71 (21.6)	30 (9.1)	—
40	232 (70.7)	—	176 (53.6)	235 (71.6)	—	56 (17.1)	—
45	285 (86.9)	—	198 (60.3)	264 (80.5)	—	87 (26.5)	19 (5.8)
50	344 (104.9)	—	220 (67.0)	293 (89.3)	—	124 (37.8)	49 (14.9)
55	408 (124.4)	—	242 (73.8)	323 (98.4)	—	166 (50.6)	85 (25.9)
60	477 (145.4)	—	264 (80.5)	352 (107.3)	—	213 (64.9)	125 (38.1)

Clearance Distance, X_C, equals the vehicle speed in meters (feet) per second times the Yellow Interval minus 1 second reaction time. This is the distance the vehicle would travel during the Yellow Interval if the decision were made to continue and not stop. Example: At 50 mph and a Yellow Interval of 4.0 seconds, X_C = [(50/60)x88] x (4-1) = 220 feet (67.1 meters).

Figure 306.05-01 Driver Dilemma Zone

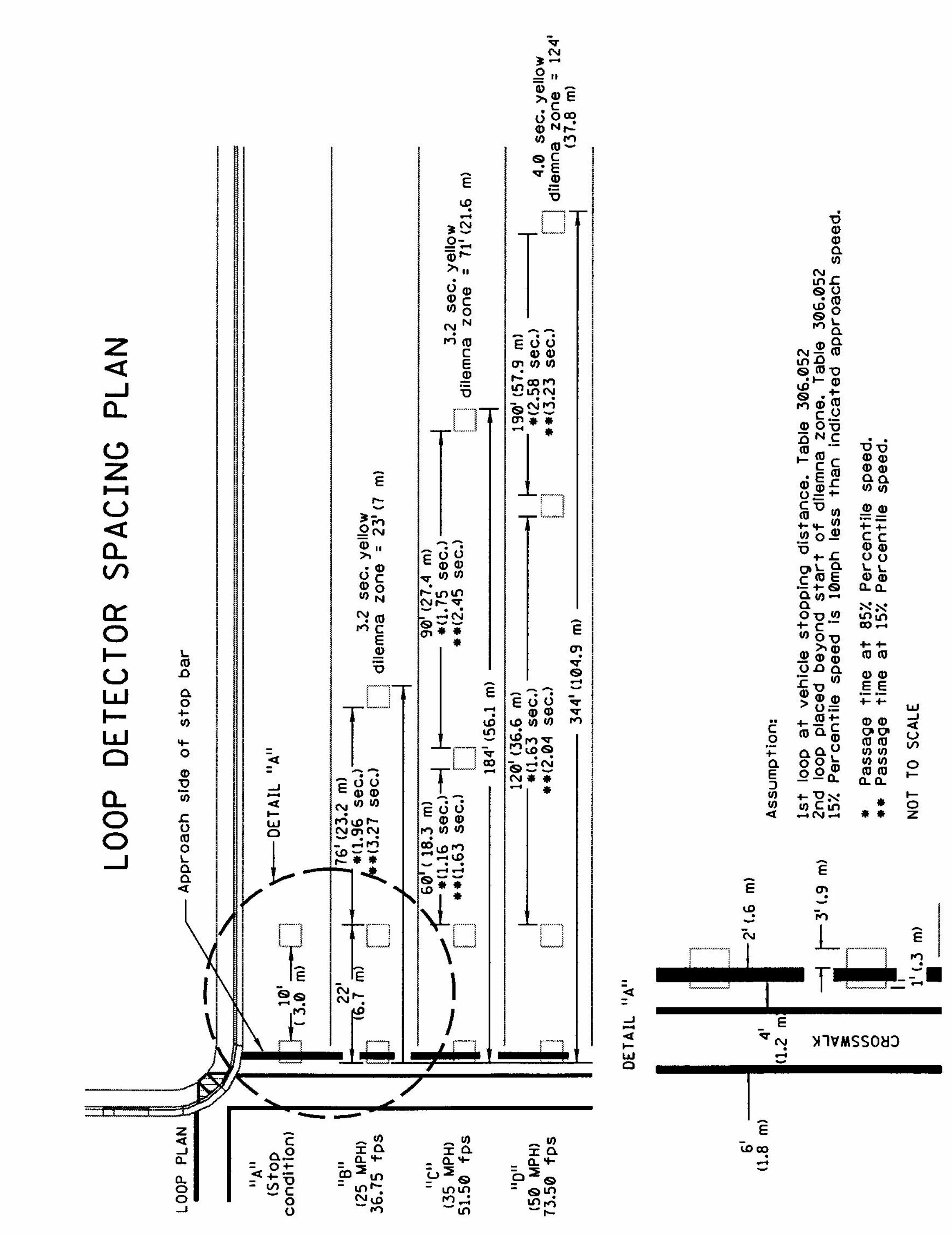


Figure 306.05-02 Loop Detector Spacing Plan

306.06 Minimum Green Interval. The minimum green interval is the time for one vehicle to move into the intersection from the point of detection. ITD uses presence loops up to the stop bar so there is no need for extra timing for the vehicle to move from the last loop into the intersection. Normal starting delay of the first vehicle in queue at a signal is 3.7 seconds, but this value may vary between geographical areas. Accordingly, the minimum green interval should be at 4.0 seconds to accommodate this startup delay. It is desirable that actuated traffic signals provide short, snappy, operations responding quickly to traffic demands when there is very little traffic. Therefore, the minimum green interval when there is stop bar presence detection should be held from 4.0 to 5.0 seconds. It has been noted at some large intersections that some drivers hesitate if they observe a yellow indication shortly after clearing the presence detector. If this appears to be a significant problem at an intersection, it may be desirable to lengthen the minimum green 1 or 2 seconds so the single vehicle is farther in the intersection before a yellow is displayed.

306.07 Passage Time Interval. The passage time interval, or vehicle interval or extension interval as it is sometimes called, serves two functions at normal actuated intersections. It sets the amount of gap that will be tolerated between successive vehicles without causing termination of the phase and it provides time for a vehicle traveling at reasonable approach speed to reach the intersection after crossing the detector if normal pulse actuation is used. When multiple loop advance detection is used, as long as the approaching vehicles provide detector impulses at less than the passage time, the signal will hold in green. Once a traffic gap greater than passage time occurs, the signal cycles to other signal phases.

The loop detection and vehicle passage time becomes somewhat distorted for a number of reasons. First, the actual vehicle detection time gap is shorter than the apparent time gap in that a vehicle activates a loop on entry and only deactivates when the vehicle leaves the loop. Therefore, the vehicle length and loop size reduce this time gap. Secondly, the multiple loops and number of approach lanes can distort the required passage time. The controller responds to detector actuation providing a new passage time with each actuation. Therefore, as a vehicle crosses additional loops in a single traffic lane or other vehicles cross a loop in adjacent lanes, a new passage time interval is established to hold the signal in green until that vehicle gets to the intersection.

These passage time intervals are reset because of the multiple loops and lanes frequently resulting in excessive green time. This excessive green time is apparent at intersections because the signal holds in green after the traffic has cleared the intersection.

The passage time between detectors for the ITD multiple loop design varies from 1.2 to 2.6 seconds, dependent on loop spacing. The passage time interval should never be longer than the vehicle passage time between loop detectors and can usually be shortened because of multiple actuations from other lanes and vehicles. The initial controller settings for passage time interval should reflect the minimum vehicle travel times for the signal loop detector design. Usually, a passage time of 2.0 seconds or less will be adequate for most intersections. Separate turn lanes with presence detection will hold the green indication as the queue moves into the loop detection. Accordingly, a passage time interval is not needed and is usually set at zero. Intersection operational review in both the peak and off-peak periods may indicate excessive green extension requiring some reduction in the passage time interval for each detection actuation. Conversely, when the green indication is terminated prematurely to service another approach, the passage time interval should be increased to extend the green.

Another way to set the passage time is to determine how much distance between vehicles you want to allow before the green interval is terminated. For example, a vehicle traveling at 25 mph covers nearly 37 feet (11.3 meters) per second. If you want to allow a gap of 75 feet (22.9 meters) between vehicles before the green interval is terminated, the passage time interval should be set to 2 seconds (75 ÷ 37 = 2).

The passage time interval should be used to fine tune signal operation since it determines how "snappy" or "sluggish" the operation may be.

306.08 Maximum Green Time. The maximum green interval limits the time a phase can hold in green during each cycle and it begins timing when there is a detection actuation on another phase. Maximum green is usually set to accommodate peak hour traffic queues that are 1.2 to 1.3 times the average queue length. If the passage time interval is short, the timing should not normally time out on maximum green except during the peak hour.

If the controller provides two maximum timing intervals, then one can be used for the peak traffic periods and the other for normal traffic. In coordinated systems, the maximum green shall exceed the coordinated green time. It is not desirable to set maximum green intervals too high because there could be unnecessary delays when the phase goes to maximum times each cycle due to detector failure causing full-time actuation.

306.09 Recall Features. The controller recall features can be used to recall the signal phasing back to a specific phase even though it has not had a detector actuation. The recall features can be used for a number of applications as follows:

Locking Call (Memory) – Locks or remembers a vehicle actuation on a specific phase. The signal controller will service this phase even if the vehicle has exited the approach. This recall is used when the stop bar loops are not functioning or when the roadway is snow covered and lane lines and stop bars are not visible.

Minimum Green Recall (Extendible Recall) – Recalls to a specific phase and provides a minimum green interval that can be extended with additional actuations. This recall should be used to recall a signal to a major street green interval during light volumes.

Maximum Recall – Recalls to a specific phase and provides a maximum green interval for that phase. It should be used where there is total detection failure and the maximum time is needed to clear queued traffic. This recall essentially puts signal controller into fixed time operation.

Pedestrian Recall – Recalls to a specific pedestrian phase each cycle and provides the full pedestrian timing interval. It should be used where the pedestrian actuation must be guaranteed each cycle or the pedestrian actuation is inoperable.

Soft Recall – Recalls to a specific phase and provides a minimum green interval that can be extended with additional actuations. Similar to Extendible Recall except the phase is only served if no other "real calls" exist.

306.10 Green Times For Coordinated Operation. Under coordinated operation, all green times and clearances must fit within a background cycle length so that the signal's operation may be timed to achieve coordinated operation. The following procedure can be used to determine the phase green times for coordinated operation.

1. Use the cycle length that has been determined for the control area. If not yet determined, begin with the intersection in the control area that will probably control the cycle length, assume a cycle length, and iterate through this procedure until the total of all required green times and clearances are less than or equal to the cycle length.

2. If the controller is actuated, use the movement volumes for the period under consideration to determine what phases and overlaps will be the normal sequence for the period.

3. Determine the total of all of the required phase clearances. Do not count the overlaps if they were accounted for in a previous phase.

4. If hourly movement volumes are used, multiply them by a factor of 1.1 to 1.3 to allow for expected queues due to random arrival. If the volumes being used are for the peak 15 minutes or less, no factor need be applied.

5. Convert volumes to vehicles per cycle.

6. Calculate lane volumes for each phase to determine the critical lane. Be sure to account for the effect of phase overlaps. In addition, if left turns can move on a normal circular green signal, reduce those left-turn volumes by 1 to 1.5 vehicles per cycle. Furthermore, if there is more than one lane for through traffic, be sure to adjust the critical lane volume for any imbalance in lane utilization. Such imbalance may result from a heavy right-turn volume or from a heavy turn movement downstream of the intersection that has an effect at the intersection.

7. Calculate the green time needed for through and right-turn traffic and for protected left-turn traffic for each phase from the following equation (reference 9).

   $$G = 3.7 + 2.1N$$

   Where: G = needed green time in seconds.
   N = number of vehicles in the critical lane.

8. Calculate the green time needed for unprotected left-turn traffic for each phase from the following equation.

   $$G = 3.7 + 2.1N + 2.7L$$

   Where: G = needed green time in seconds.
   N = number of opposing through and right-turn vehicles in the critical lane.
   L = number of left-turn vehicles in the critical lane.

9. Compare the required phase green times with the phase minimum green times and with the required phase WALK and pedestrian clearance times and use the larger of these times in each case.

10. Add all of the phase green times to find the total required green time. Add the total clearance times to this to find the required cycle time. If the required cycle time is less than or equal to the cycle length under consideration, the intersection will function properly. If there is excess time available, assign it to the coordinated phase. If there is more than one coordinated phase,

divide the excess among them as appropriate. If the total exceeds the cycle length under consideration, the intersection may not operate without congestion. If the total is within five seconds of the cycle length under consideration, the intersection will probably operate acceptably, provided one or more of the vehicle greens can be reduced as needed without violating any minimum times. If the difference is more than five seconds, it would be best to consider a higher cycle length.

SECTION 307.00 - INSTALLATION AND MAINTENANCE

307.01 Installation Responsibility. The Department is responsible for the installation of traffic signals on the state highway system. ITD is not responsible for traffic signals off the state highway system (reference Administrative Policy A-12-16).

Cost participation and maintenance responsibilities are summarized below:

- State Highway Intersections With Public Roads That Are Not State Highways: Traffic signal installation, maintenance, and operation costs shall be paid in proportion to the number of approach lanes under the jurisdiction of each responsible agency. The installation, maintenance, and operation requirements, with costs and responsibilities defined, shall be covered by a cooperative agreement with the local agency.

- New Development for Special Use Groups: When installation of a signal at an existing public road is required by new development, the developer or special use group shall assume 50% of the installation costs unless otherwise agreed to by the local jurisdiction. The Department and local jurisdiction shall share in the additional installation costs in proportion to the number of approach lanes in their jurisdiction. If the development requires additional traffic control equipment or traffic signal control is needed to access private driveways or future public road approaches, the developer or special use group shall bear all design and installation costs including construction inspection.

Operation and maintenance costs will be shared by the Department and local jurisdiction in proportion to the number of approach lanes under the jurisdiction of each agency. The proposed installations require approval of the Traffic Engineer. The installation, maintenance, and operation requirements, with costs and responsibilities defined, shall be covered by a cooperative agreement with the local agency.

- School crossing traffic signals meeting the minimum requirements of the MUTCD may be installed and maintained by the local agency at their full cost, subject to approval by the Traffic Engineer.

- Intersection control beacons (flashing beacons) may be installed and maintained at public road approaches and major private approaches when justified by an engineering study. Costs shall be apportioned on the same basis as for traffic signals. Proposed installations require approval of the Traffic Engineer.

307.02 Project Approval. Traffic signal installations may be constructed either as a portion of a federal-aid project or as a state improvement project. Each installation shall be approved by the Traffic Engineer.

Project Concept Reports ([ITD-783](ITD-783)) for highway construction projects should include traffic signal justification and cost data if a traffic signal is planned as a portion of the construction contract. The traffic signal traffic engineering study (section 302.02) should be submitted with the ITD-783 Concept Report or approved prior to concept approval.

Traffic signal installations and improvements not covered by a project approval process shall be coordinated with the Headquarters Traffic Section for approval and programming of the necessary funds.

307.03 Agreements. General agreement types are:

- Local Agency Agreements: Agreements are required between the Idaho Transportation Department and communities for all traffic signal installations to define work to be done by each party, cost participation, maintenance responsibilities, ownership of signal equipment, and other special requirements. In all cases, the District Traffic Engineers should review the traffic signal installation with city officials and secure their approval prior to preparation of formal agreement.

    - **Cooperative Project Agreements:** If a Cooperative Project Agreement is required for other items, it shall also include the agreement clauses for traffic signals. The Headquarters Traffic Section shall coordinate traffic signal requirements with the Headquarters Roadway Design Section.

    - **Traffic Signal Agreements:** If an agreement is required only for traffic signals, it will be prepared by the district and coordinated by the Headquarters Traffic Section with the Headquarters Roadway Design Section for community approval. The contract shall not be awarded or construction by state forces started until this agreement has been signed and payment received from the local agency.

- Energy Supply Agreements:

    - Urban Areas: The payment of electrical services and any necessary agreements are the community's responsibility within their city boundaries.

    - Rural Areas: (Idaho Power Company) An addendum to the Energy Supply Agreement with the Idaho Power Company is required. The District Traffic Sections will prepare these addendums.

(Utah Power and Light Company) An Electrical Service Contract with Utah Power and Light Company exists in District 5. The district will prepare an addendum for this contract.

The local agency or state, as appropriate, shall be responsible for all electrical service billings including any power usage by the contractor for traffic signal testing and operations.

- Railroad Agreement: An agreement will be required with the railroad company when any portion of a traffic signal installation is located within railroad right-of-way or when traffic signal preemption equipment is required. The Headquarters Traffic Section will coordinate the traffic signal requirements with Utilities Engineer for preparation and completion of these railroad agreements.

307.04 Electrical Service. The source and availability of electrical energy must be discussed and coordinated with the utility company. Information will have to be furnished to the utility company on voltage, electrical load, desirable service point, and special electrical control equipment requirements. Special electrical service requirements such as line extensions, service control equipment, and extra service connection costs should be coordinated with the Headquarters Traffic Section.

It is recommended that the traffic signal contractor or subcontractor be responsible for scheduling electrical service for all traffic signal installations and pay all costs associated with the electrical service. This provides the contractor the opportunity to deal directly with the utility company and obtain electrical service when it is needed to meet the work schedule. The contractor needs to be advised that there is usually a payment for a new electrical service drop and that payment must be included in his lump sum bid for the traffic signal installation. This requirement can be implemented by including the following contractor's note in the contract:

"It will be the contractor's responsibility to contact the appropriate power company to make the initial power hookup in a timely manner. Fees charged by the power company, if any, shall be paid by the contractor and will be considered incidental to the cost of traffic signal installation."

307.05 Construction Inspection. Traffic signals are considered a specialty item for Idaho contractors as they have not had extensive experience in this work. Accordingly, it is necessary that construction be watched closely and special guidance provided on material requirements and construction details. The District Traffic Engineers and Traffic Signal Technicians should assist the Resident/Regional Engineer on any problems or questions that develop. A representative of the Headquarters Traffic Section will be available when requested to provide field assistance and consultation on special problems.

When traffic signal construction projects are inspected by representatives of District Traffic Section or Headquarters Traffic Section, their comments should be reported on Form DH-1406, Construction Inspection Report, to the Assistant District Engineer - Operations with copies to the District Traffic Engineer and the Headquarters Traffic Section.

Electrical subcontractors should attend the pre-construction conference on all projects with traffic signal work. If this is not possible, then a separate meeting with the electrical subcontractor is recommended to answer all questions prior to construction. The following items should be discussed with the electrical subcontractor:

- Review project plans and specifications.
- Discuss material approval requirements.
- Clarify any special construction or material requirements.
- Schedule of work.
- Shop testing and control equipment acceptance.
- Traffic control plan for construction.
- Use of Loop Detector Test Report form.

It is important that the traffic signals be properly installed to prevent excessive future maintenance costs. Regular construction inspection personnel should be able to handle most inspection work after some experience and indoctrination. Items that have created problems in the past include conduit installation, anchor bolt placement, location of expansion fittings, signal detection loops, and installation of signal equipment and control cable. Refer to Section 308.02 for information regarding signal pole locations and mast arm lengths.

307.06 Operational Review. Following construction, the district should make an operational review of the traffic signal to assure it is providing proper traffic operations. The simplest review should essentially provide answers to the questions listed below. A more detailed guide for operational reviews is available in the FHWA publication “Traffic Reviews for Operational Safety.”

- Does it handle traffic as planned during AM, noon, and PM peaks?
- Do motorists use the intersection properly?
- Do pedestrians cross as planned?
- Can efficiency be improved?
- Is additional signing needed?
- Does traffic follow the striping and other desired travel paths?
- Are phasing and timing adequate? Are all features of the design physically located in conformance with good safety practices?
- Write a brief operational report.

These reviews normally uncover minor problems that can have major detrimental influences on pedestrian or vehicular safety and operational efficiency that may result in liability claims. The operational review should be covered in a letter to the Headquarters Traffic Section by the District Traffic Engineer outlining the operational review of the intersections addressing the above questions, indicating minor revisions the district will make noting design standards that may need revision and noting any major operational problems with the signal installation.

307.07 Traffic Signal Inventory. The Department has a Traffic Signal Inventory on all traffic signals on the state highway system. It provides a current inventory of traffic signal control hardware, intersection geometrics, and signal timing. It is important that the database be updated for new installations or revisions are made including any timing changes. Additional information on the inventory system is available from the Headquarters Traffic Section.

307.08 Maintenance Responsibility. The ability of traffic signals to foster safe and efficient traffic flow in a cost-effective manner is dependent upon their proper operation and the timing set on them. Both of these aspects require proper maintenance in order to function properly.

Traffic signal maintenance on the state highway system outside the corporate limits of communities is the responsibility of the state. ITD is not responsible for maintenance of traffic signals located off the state highway system.

The maintenance of traffic signals within corporate limits of communities is covered by the Cooperative Traffic Signal Agreement. ITD shall assume no maintenance responsibilities for a traffic signal that did not involve state participation in the construction unless an agreement specifically assigns the state that responsibility.

State-city maintenance responsibilities shall generally be:

- The community will assume the responsibility for all operation costs and some maintenance costs, if specified.

- ITD will furnish signal equipment replacement parts necessary to maintain standard operations.

- ITD will perform the necessary maintenance to provide standard operation of the traffic signal, unless otherwise specified.

307.09 Preventive Maintenance. The goal of preventive maintenance is to inspect the equipment and the timings according to a plan in order to detect and correct potential problems and actual failures that may have gone unreported. This type of maintenance pays dividends in three ways. First, it maximizes the proper operation of the traffic signals so that the motoring public actually receives the benefits of the signals to the fullest extent.

Second, preventive maintenance reduces overall traffic signal maintenance costs by reducing costly trouble calls. Finally, an effective preventive maintenance program will reduce complaints and adverse reactions from citizens that result from malfunctioning equipment and defects that often go undetected and unreported for long periods.

Preventive maintenance must begin with signal design that is developed to minimize the need for maintenance and to facilitate corrective maintenance when failures do occur. Not only must the signal designs incorporate these aspects, signal personnel and contractors must faithfully install the signals according to these designs as set forth in the plans, the Typical Drawings, and the Traffic Signal Specifications.

307.10 System Timing Maintenance. The timing plan that is stored in the local controller units should not only be updated periodically, it should be checked at least once a year to detect problems that cannot be detected by the annual preventive maintenance of the intersections. If problems are identified, a cooperative effort between the district traffic engineer and the signal technicians will probably be necessary to determine whether the problem is due to incorrect settings or hardware.

Time clocks, program timers, and the computer system's scheduler may need to be updated to reflect changes to and from daylight savings time, the start and end of school, school holidays, special holidays, and special events.

307.11 Corrective Maintenance. The topic of corrective maintenance does not need to be belabored. When a traffic signal breaks, fix it! However, there are several guidelines that are appropriate in this context.

Any failure that affects a signal's ability to serve traffic as intended should be corrected as soon as possible. There may be times when such failures cannot be remedied immediately, but it should be realized that, as long as a signal is not operating as intended, the public will not be receiving the maximum benefit from it. Furthermore, there may be an undesirable exposure to tort liability.

In any case, signal maintenance personnel must never, for any reason, leave any signal in a state that may foster unsafe operation.

All corrective maintenance should be performed with maximum regard for the safety of both the maintenance personnel and the public (vehicles and pedestrians).

SECTION 308.00 - TRAFFIC SIGNAL DESIGN

308.01 Preliminary Plan Requirements. The following list indicates the type of information that should be available on the site sketch for the preliminary design review:

- Existing site plan of intersection extending at least 150 feet (45.7 meters) on each approach with approach speeds of 25 to 35 mph (scale 1" = 20') and 350 feet (106.7 meters) on each with approach speed of 50 mph (scale 1" = 20' or 1" = 40').

- North arrow, roadway stationing.

- Street names and route numbers.

- Existing pavements lane and shoulder widths, all pavement markings, right-of-way and property lines, approximate grades, drainage pipes and inlets, curb radii (curbed or uncurbed), driveways, and barriers.

- Utility poles, street lighting, traffic islands, traffic signal poles, vehicular detectors, signal heads, and controller, if any.

- No parking and restricted parking zones, hours, etc., bus stops, and direction of one-way streets, if any; all traffic control signs and the speed limits on each approach.

- Existing buildings and locate any obstruction to sight distance for the driver approaching the intersection. This will include trees, shrubbery, fences, billboards, walls, etc.

- Location of any railroad grade crossings within 300 feet (91.4 meters) of the intersection. Give name of the railroad company. Indicate existing protection and whether siding, mainline, etc.

- Distance to nearest existing traffic signal on each approach, if one mile or less; municipal boundaries if within the area of the plan and identify the municipality.

- Condition of pavement on all approaches where loop detection is proposed.

- Overhead wires, underground utilities, fire hydrants, basements, and any other appurtenances that could involve the signal design.

- Approximate location for signal heads and traffic signal poles.

Supplementals often furnish additional information ~~in~~ to that shown on the plan sheets. Two photos taken from each street approach, one from fairly close and the second from about 100 feet (30.5 meters) back, make a good reference for intersection details.

308.02 Signal Supports. Type of Supports: Mast arm installations shall be used where physically practical for all permanent signal installations. Span wire mountings are to be considered only for temporary installations and special situations that have prior approval from the Traffic Engineer. The proper use of mast arms enables the heads to be positioned on rigid mountings for maximum visibility.

Signal Pole Location:

Transverse Location	Horizontal Clearance* Min.	Desirable	Max.
Behind face of curb	2 ft (0.61 m)	8 ft (2.44 m)	15 ft (4.57 m)
Beyond edge of shoulder	2 ft (0.61 m)	10 ft (3.05 m)	15 ft (4.57 m)

*Horizontal clearance is measured from the face of curb or edge of shoulder to any part of the signal equipment.

When traffic signals are installed in rural areas or on high speed facilities (50 mph or greater), the signal supports should be placed as far away from the roadway as practicable.

The traffic signal pole location should provide the above clearance requirements and be positioned to provide the best location for pedestrian signal push buttons. In some cases, it may be advisable to install a short pedestal for the push button and pedestrian indications, although the hardware on a corner should be held to a minimum. A pole foundation should generally be at the same elevation as the pedestrian walkway, not located in a drainage area, and located to reduce potential collision. The contractor should be provided not only staking for pole location but also foundation elevation.

308.03 Signal Heads. Signal Head Mounting: Signal heads that are suspended over the roadway should be mounted with clamp on rigid mountings on mast arms so the heads can be positioned for maximum visibility and can be adjusted to fit changing conditions.

Pole-mounted vehicle and pedestrian heads should be mounted with terminal compartment type mounts. The terminal compartment provides easier installation and maintenance of the wiring.

Backplates: Backplates should be installed on all vehicle signal heads to increase the contrast between the signal heads and backgrounds such as the sun, street lights, and advertising signs.

Signal Head Size: All vehicle signal heads should be 12-inch (300 mm) diameter, unless 8-inch (200 mm) heads are justified under the special conditions indicated in the MUTCD. The approved lamps meeting ITE specifications are shown in Figure 308.03-01.

Pedestrian heads should be single-housing, two-section incandescent type with the man/hand symbols. The approved lamps meeting ITE specifications are shown in Figure 308.03-01. The higher wattage lamps should be used when the width of the crossing exceeds 60 feet (18.3 meters).

308.04 Signal Head Location. Another important consideration is the need to provide the proper spread or spacing between signal indications so all approaching motorists will be able to see at least one indication, even if their attention is diverted somewhat to the left or the right or their view is partially obstructed by a large vehicle.

The required dual indication for the through movement shall have a minimum horizontal separation of 8 feet (2.44 meters) with at least 20 feet (6.10 meters) total spread desirable between extreme right and extreme left signal heads.

Some difference in elevation between the signals is also desirable so at least one will be visible when the other or others are difficult to see because of sun, background lighting, or other distractions.

The mounting height of signals is the distance from road surface or sidewalk surface to the lowest part of the signal equipment.

Recommended mounting heights are:

	Minimum Ft (m)	Desirable Ft (m)	Maximum Ft (m)
Overhead vehicle heads	16 (4.88)	17 (5.18)	19 (5.79)
Pole-mounted vehicle heads	10 (3.05)	11 (3.35)	15 (4.57)
Pedestrian heads	7.5 (2.29)	8 (2.44)	10 (3.05)

Desirable locations of signal heads on two-way streets are:

- A two-lane street should have one vehicular head mounted on the pole and one mounted centered over the lane. See Figure 308.04-01.

- A two-lane street with one through lane and a left-turn bay that are both on the same phase should have one head on the pole and one head 4 feet (1.22 meters) to the right of the turn bay channelizing line. If the turn bay is a separate phase, locate one head about 4 feet (1.22 meters) left of the channelizing line, and one head centered over the right lane and one head on the pole. See Figure 308.04-02.

- A four-lane street approach without a left-turn bay should have one pole-mounted head and two signal heads mounted on the mast arm with one head located in line with the extended centerline of each lane. See Figure 308.04-03.

- A four-lane street with a left-turn bay but with no separate phase should have one pole-mounted signal head and two signal heads mounted on the mast arm with one head located in line with the extended centerline of each through lane. No signal head should be positioned in line with the left turn bay or its channelizing line because a clear distinction is desired between an unprotected left-turn move and one that is protected by a separate signal phase. If the left-turn bay is protected by a separate phase, an additional head with green arrow indication should be located 4 feet (1.22 meters) left of the extension of the left-turn bay channelizing line. See Figures 308.04-04.

- Six-lane street approaches should be treated similarly as the four-lane approaches with an additional head centered over the additional through lane. See Figure 308.04-05.

- Desirable locations of signal heads on one-way streets should have mast arms from each side with overhead signals located 10 to 12 feet (3.05 to 3.66 meters) on each side of the street centerline and a pole-mounted signal on each side. See Figures 308.04-07 and 308.04-08.

MANUFACTURER	MFG PART NO.	DESCRIPTION	ITD CAT. NO.
3M	M131-321G(V)B M131-324G(V)B M131-381G(V)B M131-384G(V)B LAMPS	Red, Yellow, Green Ball-Pole Mount Red Ball, Yellow Arrow, Green Arrow-Pole Mount Red, Yellow, Green Ball-Overhead Bracket Red Ball, Yellow Arrow, Green Arrow-Overhead Bracket 150PAR46/TS(115v) – place on materials list	567061601
Siemens ITS	SIG103A1111GGG SIG103Q1111GGG SIG103R1111GGG SIG104A1111GGG SIG104B1111GGG SIG105H1111GGG	Red, Yellow, Green Ball Red Ball, Left Yellow Arrow, Left Green Arrow Red Ball, Right Yellow Arrow, Right Green Arrow Red, Yellow, Green Ball, Left Green Arrow Red, Yellow, Green Ball, Right Green Arrow 5 Section Cluster with Red, Yellow, Green Ball; Left Yellow Arrow, Left Green Arrow	
Econolite	TP31VSG2APH0 TP33VSG2APH0 TP56VSG2APH0 TP44VSG2APH0 TP45VSG2APH0 LAMPS	Red, Yellow, Green Ball Red Ball, Yellow Arrow, Green Arrow 5 Section Cluster with Red, Yellow, Green Ball; Left Yellow Arrow, Left Green Arrow Red, Yellow, Green Ball, Left Green Arrow Red, Yellow, Green Ball, Right Green Arrow 1950L/P25/TS(130v) – place on materials list	
McCain Traffic Supply	MTSTP304PA MTSTP324PA MTSTP354PA MTSTP564PA MTSTP414PA MTSTP464PA LAMPS	Red, Yellow, Green Ball Red Ball, Left Yellow Arrow, Left Green Arrow Red Ball, Right Yellow Arrow, Right Green Arrow 5 Cluster with Red, Yellow, Green Ball; Left Yellow Arrow, Left Green Arrow Red, Yellow, Green Ball, Left Green Arrow Red, Yellow, Green Ball, Right Green Arrow 1950L/P25/TS(130v) – place on materials list	

MANUFACTURER	MFG PART NO.	DESCRIPTION	ITD CAT. NO.
McCain Traffic Supply Programmable	HPSTS3043 HPSTS3243 HPSTS3045 HPSTS3245 LAMPS	Red, Yellow, Green Ball-Mast Arm Mounted Red Ball, Left Yellow Arrow, Left Green Arrow-Mast Arm Mounted Red, Yellow, Green Ball-Framework Mounted Red Ball, Left Yellow Arrow, Left Green Arrow-Framework Mounted 150PAR46/TS(115v) – include on materials list	
TCT	PSF83C300P PSF83C311P PSF83C315P PSF84C413P PSF84C400P PSF85C500P	Red, Yellow, Green Ball Red Ball, Left Yellow Arrow, Left Green Arrow Red Ball, Right Yellow Arrow, Right Green Arrow Red, Yellow, Green Ball, Left Green Arrow Red, Yellow, Green Ball, Right Green Arrow 5 Section Cluster with Red, Yellow, Green Ball; Left Yellow Arrow, Left Green Arrow	567061106

Figure 308.03-01 Approved Traffic Signal Incandescent Lamps

MANUFACTURER	MFG PART NO.	DESCRIPTION	ITD CAT. NO.
Indicator Control Corporation	7090-0G-05-01-01-98-01	Symbol Incandescent Pedestrian Signal	567061502
McCain Traffic Supply	101SPO	Symbol Incandescent Pedestrian Signal	

Approved Pedestrian Signal Heads

MANUFACTURER	MFG PART NO.	DESCRIPTION	ITD CAT. NO.
3M	C115VAC01-976	3M Signal Head Lamps	
General Electric Co.	1950L/P25/TS (130v) 69A21/TS (120v) 150PAR46/TS	1950 Lumens 12” Signal Heads Only 69 Watts, 675 Lumens 8” Signal Heads and Pedestrian Heads 3M Signal Head Lamps	160186409 160184404 160188108
Philips	1950L/P25/TS (130v) 69A21/TS (120v)	1950 Lumens 12” Signal Heads Only 69 Watts, 675 Lumens 8” Signal Heads and Pedestrian Heads	

Approved Traffic Signal Heads

MANUFACTURER	MFG PART NO.	DESCRIPTION	ITD CAT. NO.
GELcor	DR6-RCFB-20A	Red Ball	

Approved Traffic Signal Led Lamps

Figure 308.03-02 Approved Pedestrian And Traffic Signal Heads

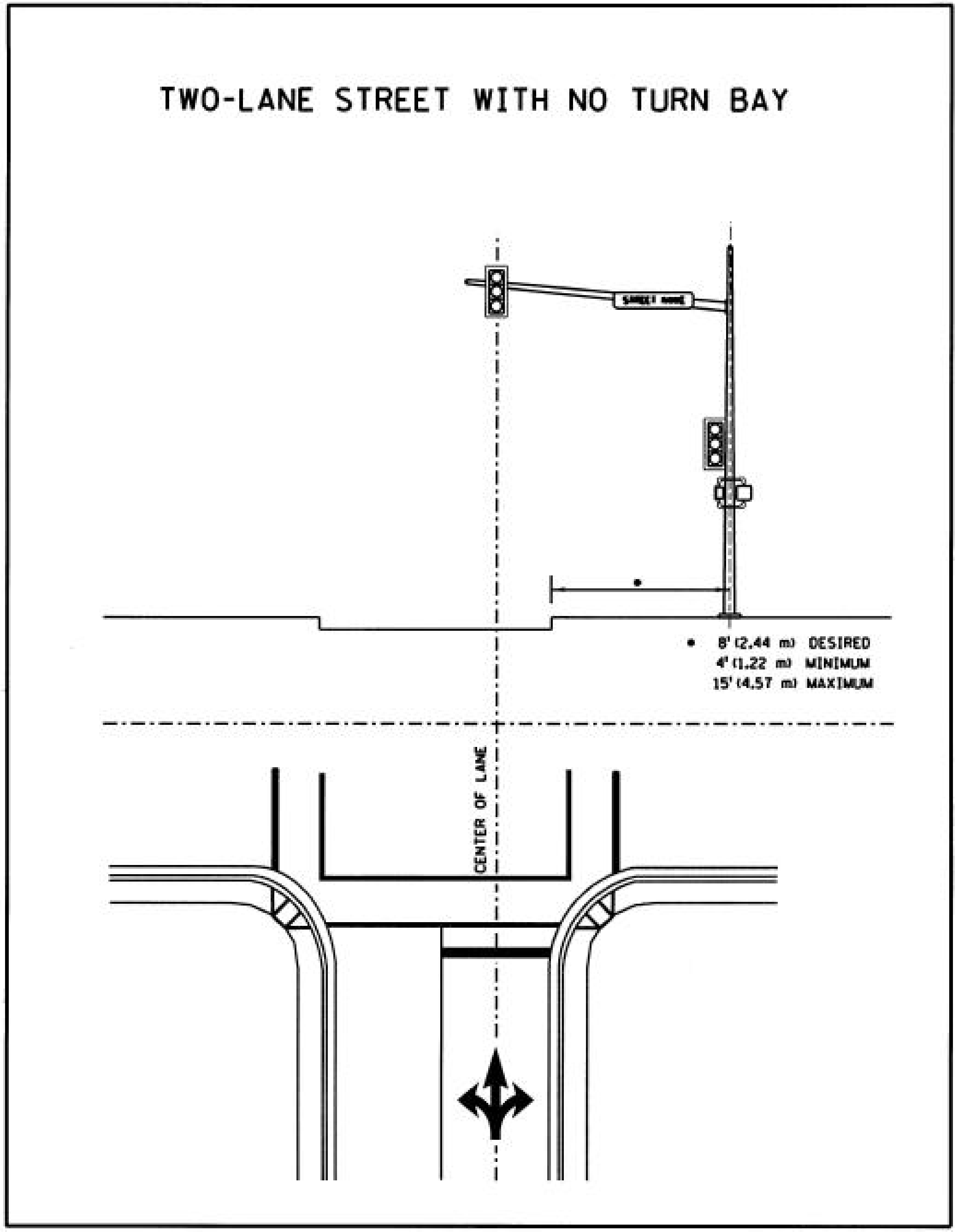


Figure 308.04-01 Two-Lane Street With No Turn Bay

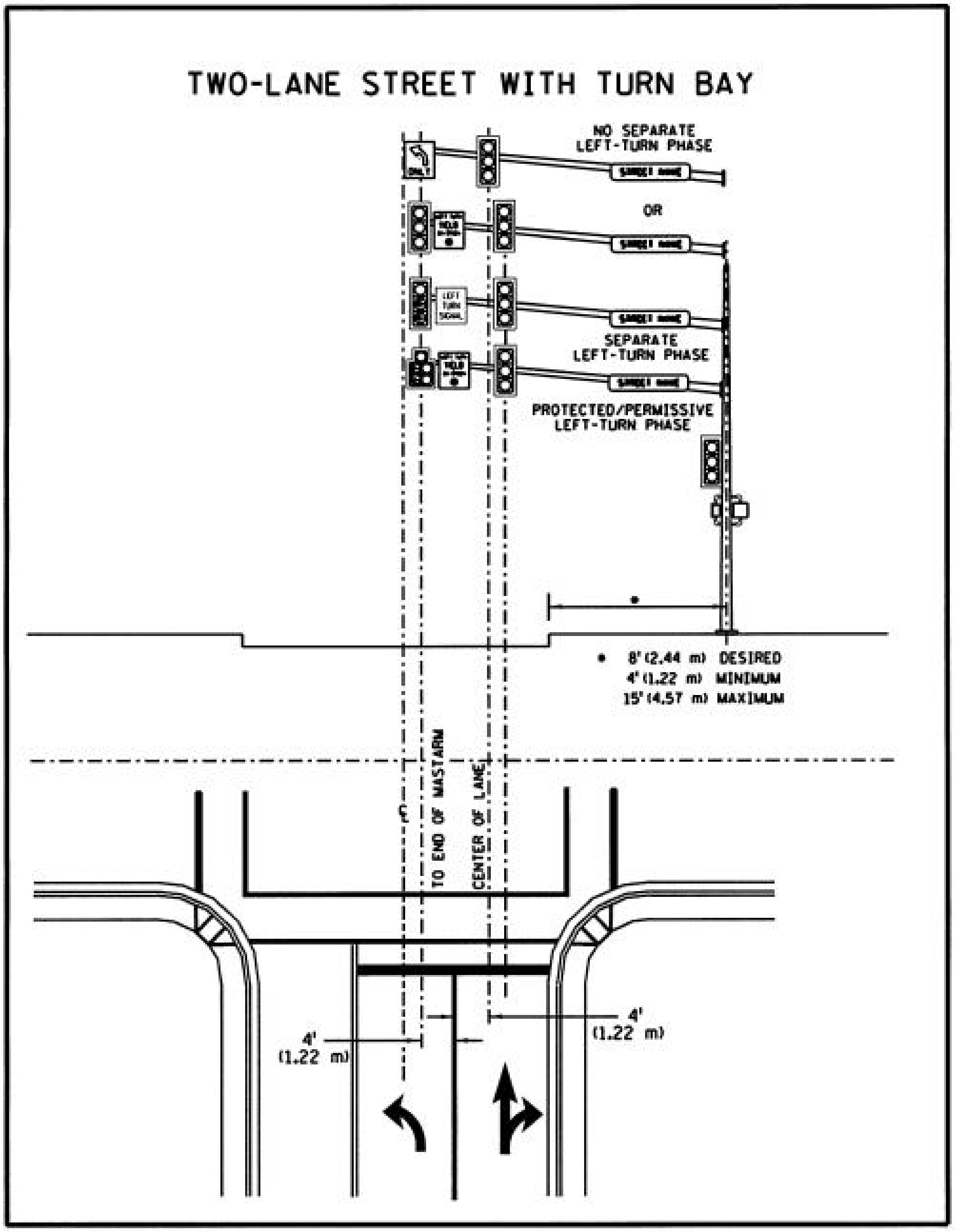


Figure 308.04-02 Two-Lane Street With Turn Bay

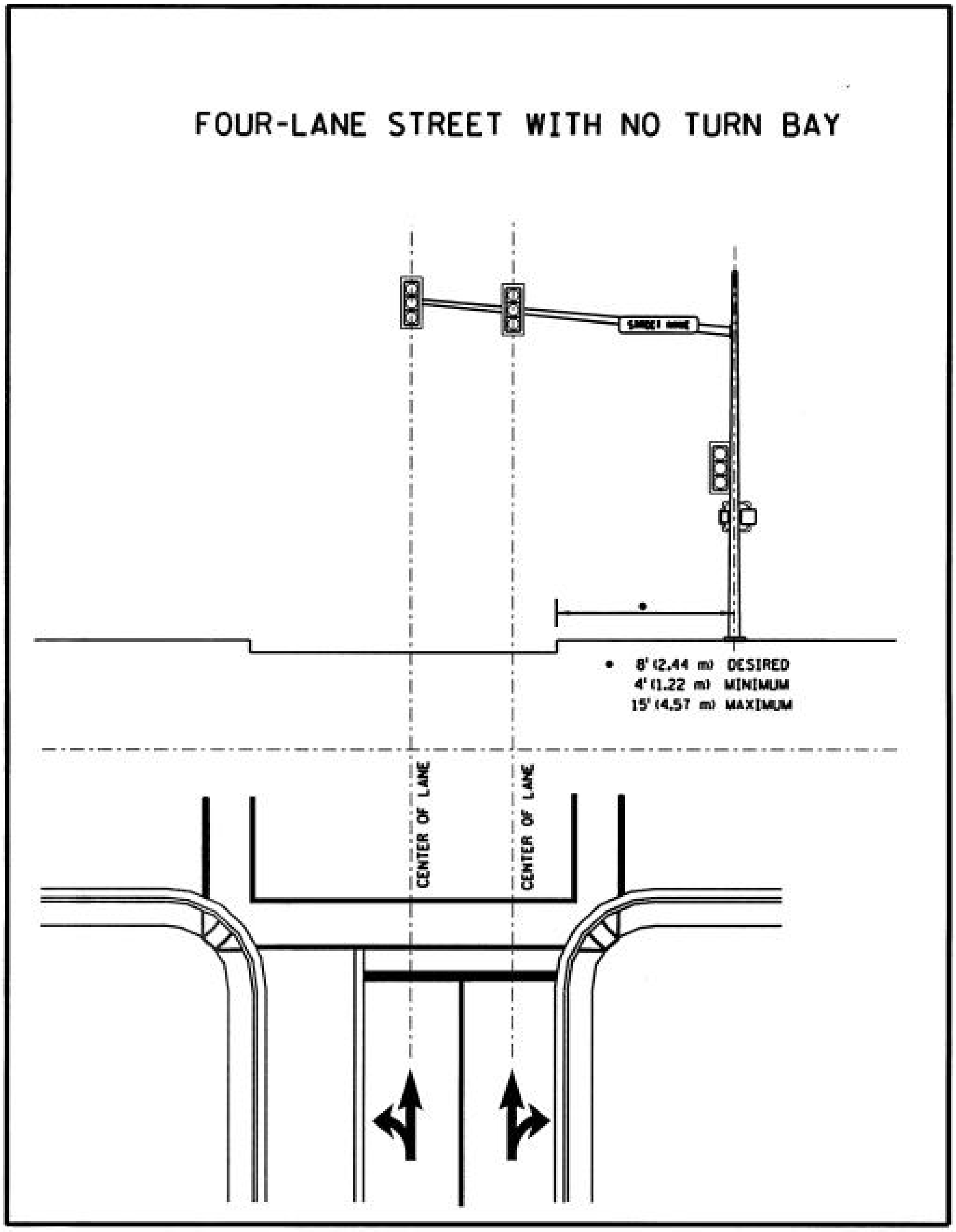


Figure 308.04-03 Four-Lane Street With No Turn Bay

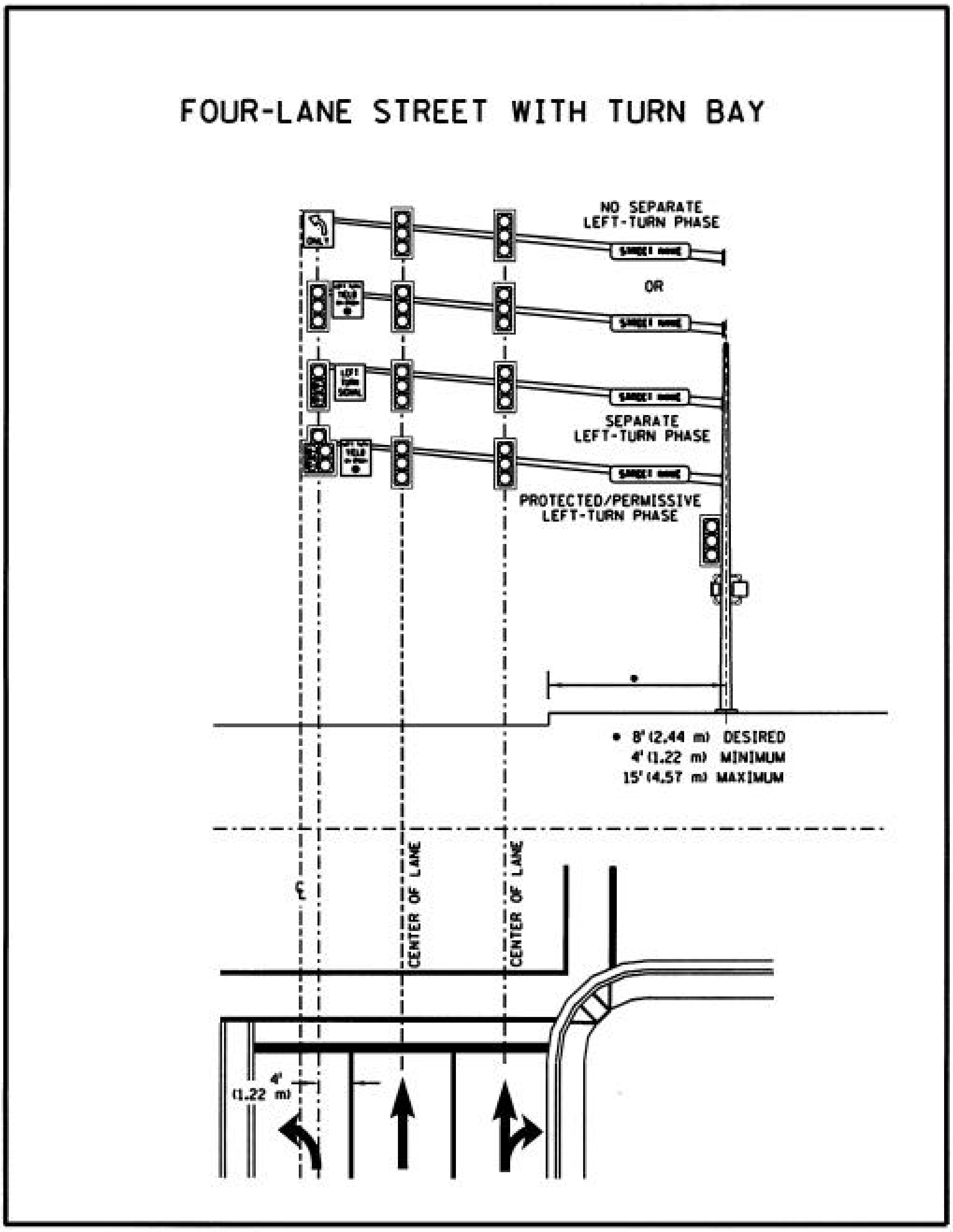


Figure 308.04-04 Four-Lane Street With Turn Bay

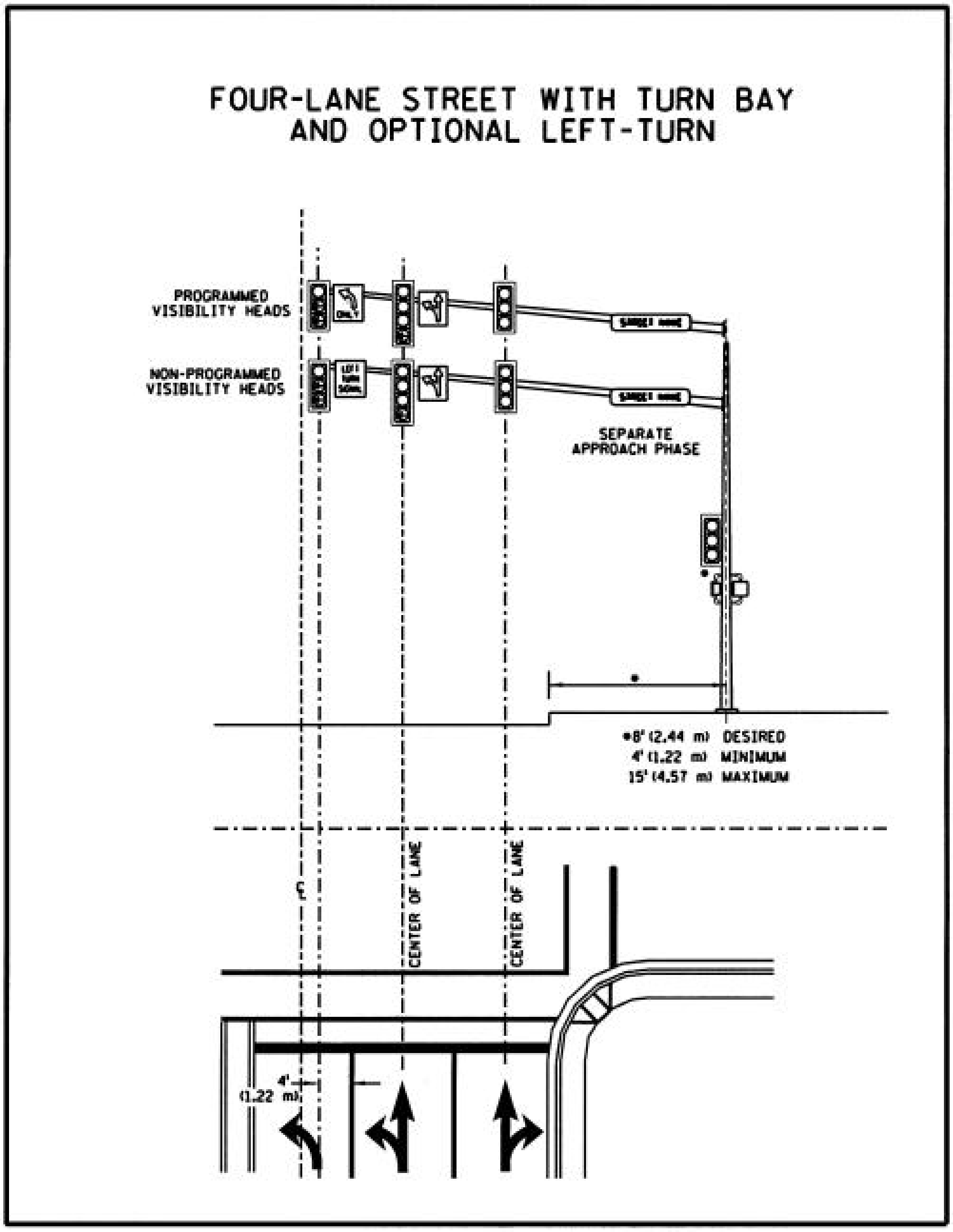


Figure 308.04-04.1 Four-Lane Street With Turn Bay And Optional Left-Turn

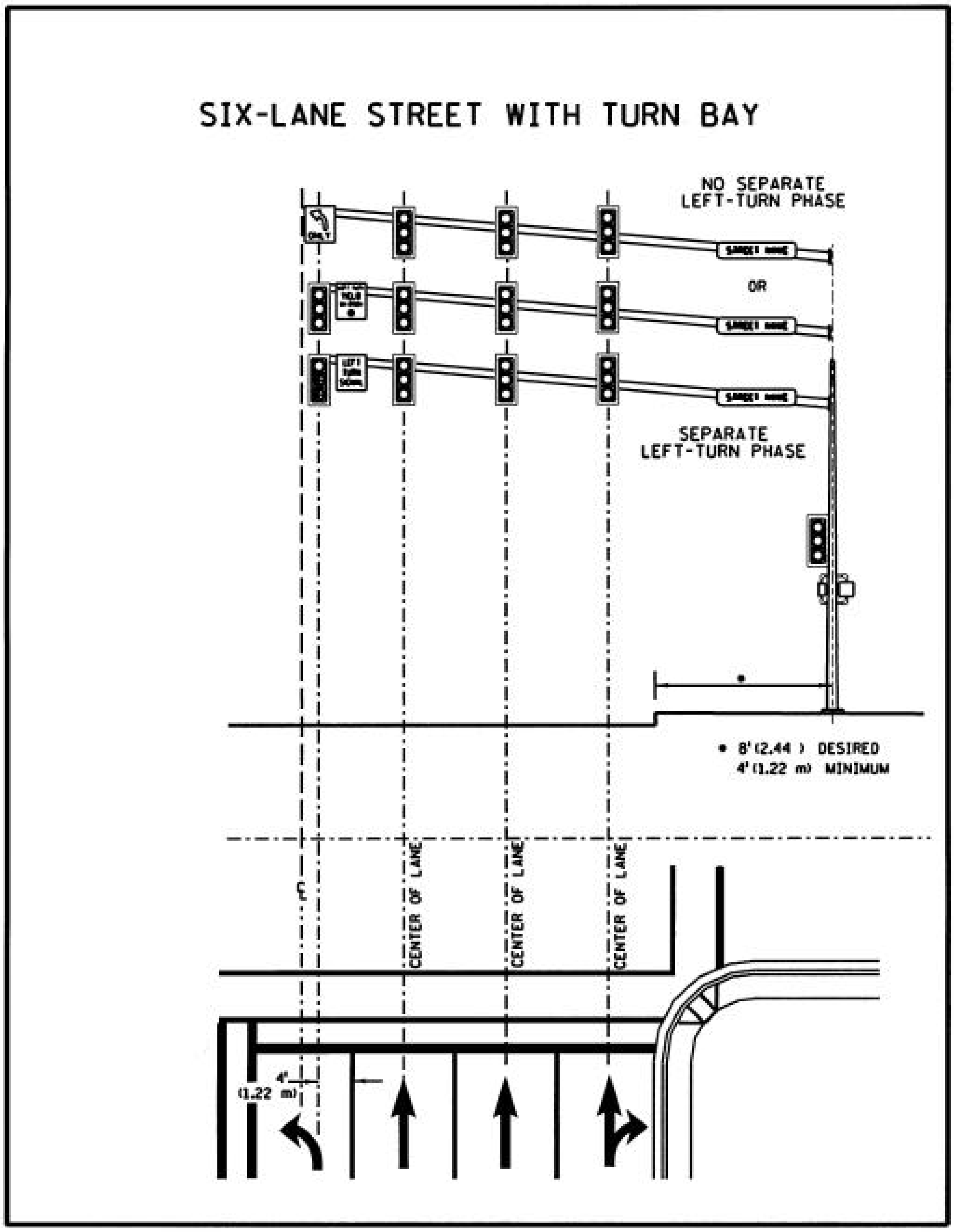


Figure 308.04-05 Six-Lane Street With Turn Bay

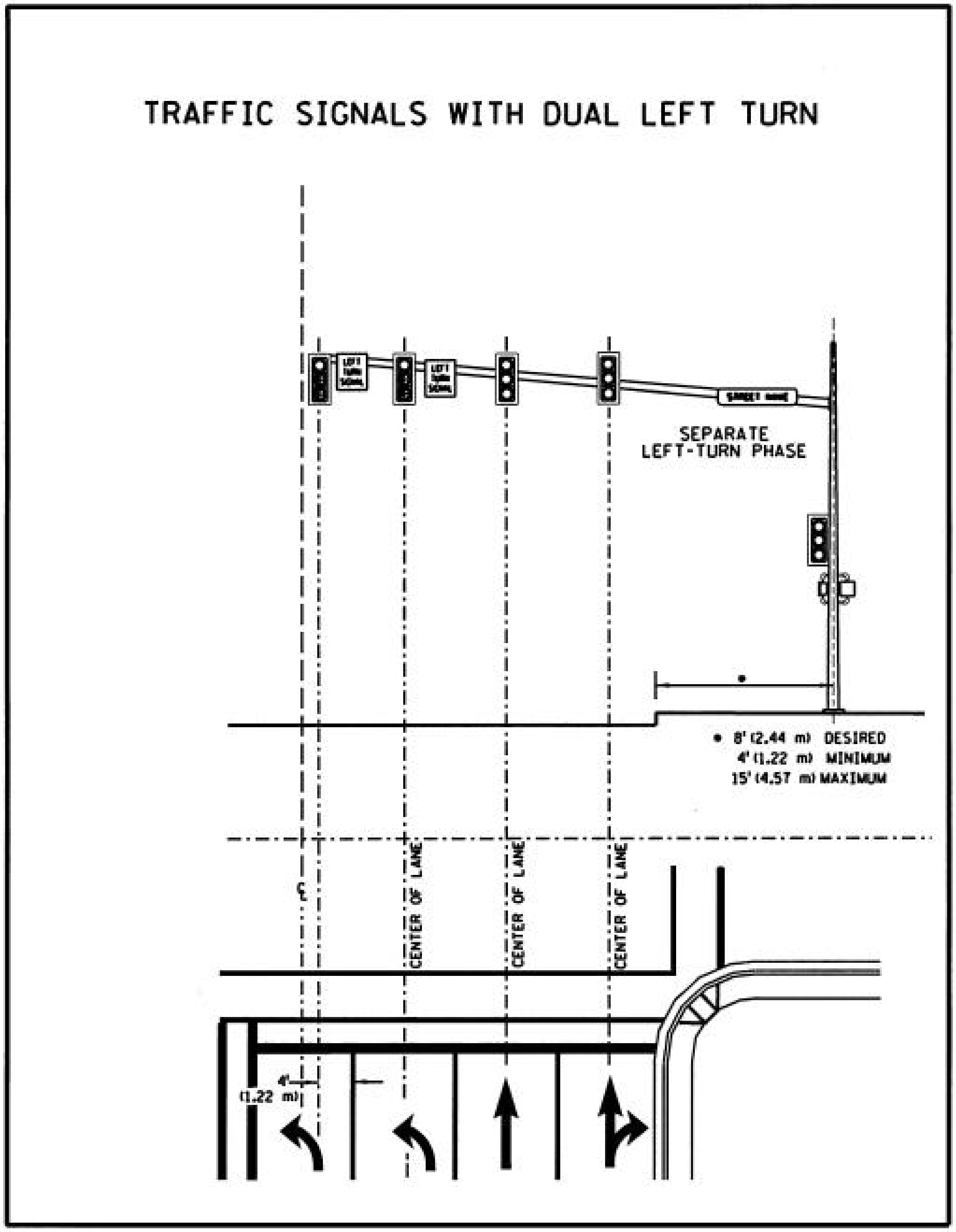


Figure 308.04-06 Traffic Signals With Dual Left Turn

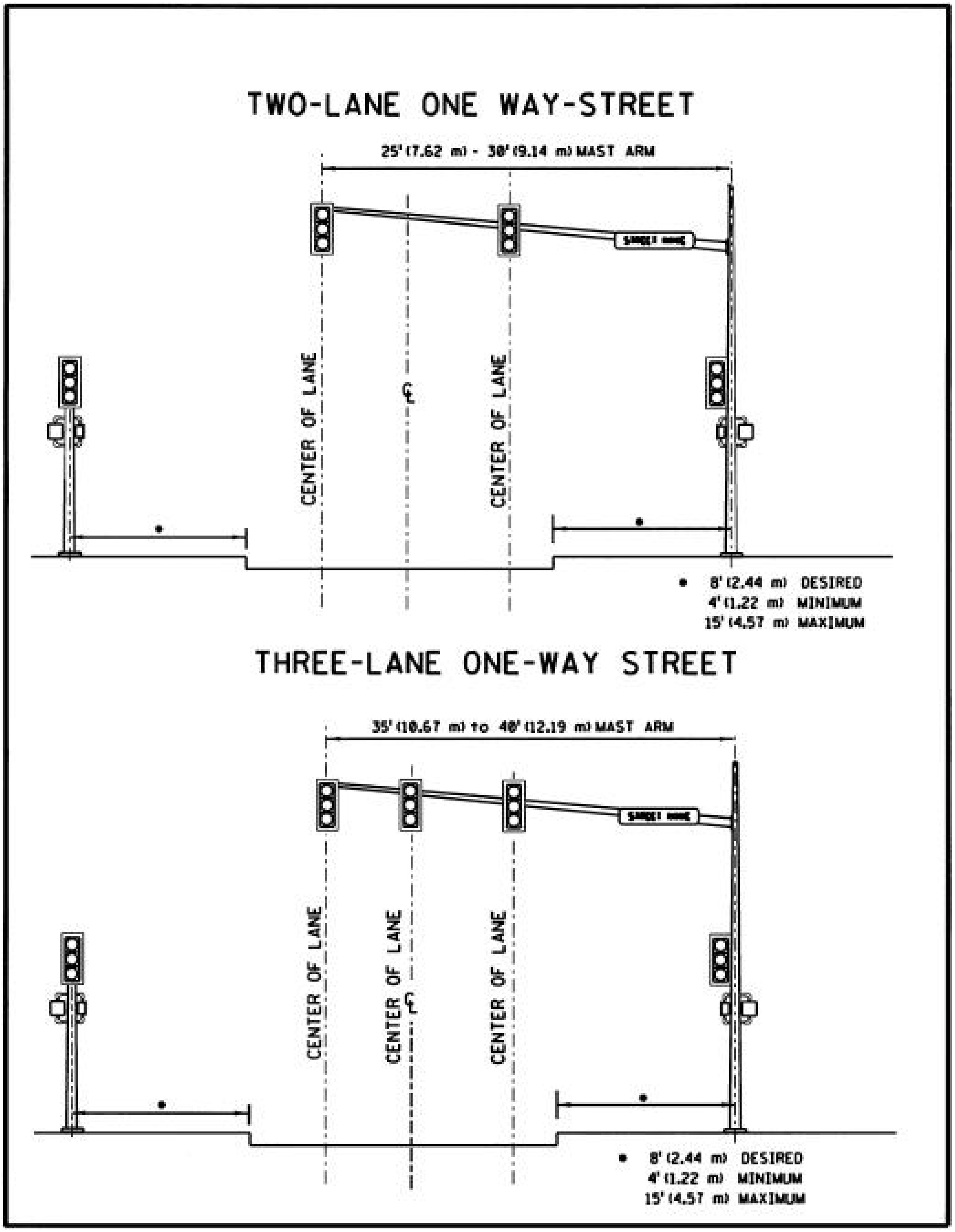


Figure 308.04-07 Two-Lane One -Way Street And Three-Lane One -Way Street

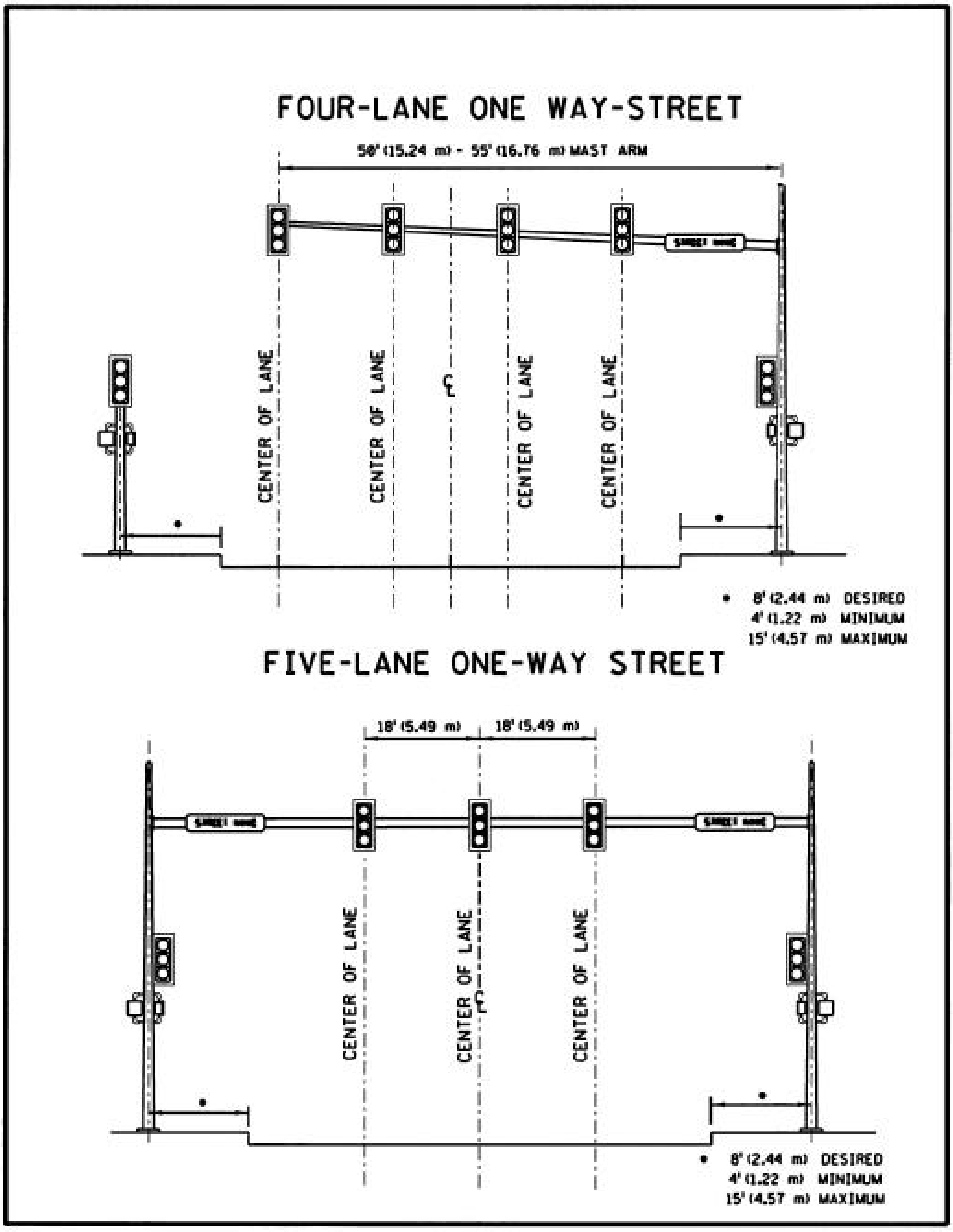


Figure 308.04-08 Four-Lane One-Way Street And Five-Lane One-Way Street

308.05 Programmable Traffic Signal Heads. Programmable traffic signal heads can be masked out so that approaching traffic in an adjacent lane or another approach does not see the signal head indication. The most frequent usage is signal indications for turn lanes where the indication may be confusing to the through traffic. The use of programmable signal heads also eliminates the need for required signing - LEFT TURN SIGNAL or RIGHT TURN SIGNAL. Programmable signals are also used at multi-approach intersections where signal head location and approach angles may result in drivers observing the wrong signal indications.

308.06 Pedestrian Signals. Pedestrian signals should be planned in all state highway traffic signal installations. They shall be installed at those locations where pedestrian facilities exist (i.e., sidewalks or walkways), there is any indication of pedestrian or bicycle traffic, or there are pending developments that will generate pedestrian traffic. In all signal installations, the traffic signal poles, controllers, wiring diagrams, and signal circuitry shall make provisions for future pedestrian signals at the intersection with pedestrian crosswalks planned in the intersection geometrics.

If a pedestrian signal is not provided for a leg of an intersection, signs must be installed that prohibit pedestrian crossings on that leg.

The Department uses an “H” type pedestrian push button/sign mounting. See Standard Drawing I-6-A.

308.07 Cabinet Location. The cabinet shall be located to meet the following considerations:

- It should not be vulnerable to traffic and should meet all roadside clearance requirements.
- The full intersection and traffic maneuvers should be visible from the open cabinet location. This permits maintenance personnel to observe traffic operations and controller timing at the same time.
- The doors of the cabinet should open away from traffic or pedestrian walkways.
- Maintenance vehicle parking should be available in close proximity to the cabinet.
- It should not be located in a drainage area or an area subject to flooding.
- It should not obstruct sidewalks, handicapped ramps, or property access.
- It should be outside the line of sight for vehicles and bicyclists using the intersection.

308.08 Vehicle Detectors. The Department normally uses loop detectors with the design and installation details covered on ITD Standard Drawing I-5, Loop Detectors. Specific details on detector design installation operations and maintenance are contained in FHWA Report IP-90-002, Traffic Detector Handbook, 2nd Edition, July 1990.

308.09 Traffic Signal Signs. Left-Turn (Right-Turn) Signal (R10-10 L or R): This sign is required when a traffic signal head provides circular green-yellow-red indications for separately controlled left- or right-turn lanes that are visible to an adjacent through lane. The signs are also required for a green-yellow arrow/circular red indication when the red indication is visible to the adjacent lane. The need for the sign can be avoided by using all arrow indications in the turn lane traffic signal head or installing programmable traffic signal lenses for all the signal head circular indications.

Left-Turn Yield on Green (R10-12): This sign is required when a traffic signal head provides circular green-yellow-red indications for a movement, in a left-turn bay, that is not separately controlled. The sign is also required when a five-section head controls the turn move with green arrow-yellow arrow indications in the protected mode and circular green and circular yellow indications in the permissive mode.

Mandatory Movement Sign (R3-5): A mandatory movement sign is required where a marked turn lane, such as a left-turn lane, is designated on the intersection approach, and it is not controlled by a signal head.

Optional Mandatory Movement Sign (R3-6): An optional mandatory movement sign is recommended where a marked lane allowing either a turn or a through movement is designated on the intersection approach. It shall be used where there is a dual turn lane involving a mandatory turn and an optional turn. The sign is also required where a lane is dropped at the intersection with the dropped lane being a mandatory turn lane.

Signal Mast Arm Street Name Sign (D3-A): Street name signs should be installed on all traffic signal mastarms as a part of the traffic signal installation. Drivers are frequently given directions referencing the traffic signals at particular intersections. A large, highly visible, street name on the signal mastarm assures the motorist identifies the appropriate signalized intersection and approaches the intersection in the appropriate lane to make a turning maneuver. This sign is described in section 177.01.

Signal Ahead Warning Sign (W3-3A): A signal ahead warning sign is usually needed for new isolated traffic signals or the first signal approaching an urban area on an arterial. This warning sign also is used to alert drivers of a new installation. A previously common practice of flashing the new traffic signal for several days after turn-on is no longer the preferred method. It is not recommended that the public be advised by a news release with a "signal ahead" sign at the intersection approaches. No signing is needed for the minor streets since this traffic essentially has less restrictive control, i.e., change from a mandatory stop for signal-controlled stop. If needed, temporarily installed signs on barricades can be used for about two weeks. These temporary signs can be a “Signal Ahead” sign or “New Signal” warning signs.

Signal Operation Change (W3-301A): This sign may be used for changes in existing signal operation and should be displayed only for those legs of the intersection that are experiencing the change. Changes in phase length do not require the sign, but changing from a leading to a lagging left may be signed to warn the motorist. Mount signs on a temporary support in advance of the intersection at a distance as determined by normal advanced warning sign placement guidelines. Post signs for not more longer than a two-week period, beginning on the effective day of the change in signal operation.

308.10 Standard Drawings. Currently, the following ITD standard drawings have been developed and are approved for traffic signal installations:

I-5 Loop Detectors
I-6A Mast Arm Traffic Signal Poles I-6B Pedestal Traffic Signal Poles
I-7A Foundation Details for Signal Cabinets
I-7B Electronic Cabinet Foundation Detail
I-7C Mastarm Signal Pole, Lighting Pole, & Pedestrian Pole Foundation Details

The traffic signal plans should comply with these standard drawings unless special circumstances require a deviation.

308.11 Typical Signal Plans. A typical set of complete traffic signal plans follow. They can be used as a guide in developing plan sheets for a specific intersection. Any questions about plan sheet details, specifications, or cost estimates should be directed to the Headquarters Traffic Section. Plans are not available at this time. Contact the Headquarters Traffic Section to obtain information.